The Impacts of Environmen
and Food Safety Regulation on U.S. Agriculture

by Bruce L. Gardner

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Executive Summary

America's food and agriculture sector has been outstanding in meeting consumers' demands for wholesome, nutritious food that is reasonably priced, while helping to feed the world's five billion people, providing over half the world's food aid in cereals. It also is a large part of the U.S. economy, providing up to fifteen percent of the labor force with jobs. Moreover, agricultural productivity continues to rise, even as productivity in the non-farm economy has lagged.

Cost-Benefit Analysis

A potentially serious threat to these successes is emerging environmental and food safety concerns leading to regulations on the sector that could seriously undermine its strength. Farmers and the food industry are concerned that prospective regulations will be based more on emotion than fact, causing significant economic harm, while generating few environmental or food safety benefits. As pressures grow to develop new agricultural regulations to meet environmental and food safety goals, it is crucial that policymakers and the public understand the potential cost and benefits of such regulations. Policymakers and the public need to understand the strengths and vulnerabilities of the U.S. agricultural economy before they consider changes in regulatory policy.

Agriculture Protects Environment

Although numerous instances have been cited of the detrimental effects of modern agriculture on the environment, the data indicates that there has been an overall environmental improvement. Soil erosion, probably the most serious environmental problem to face U.S. agriculture, has become less serious due to improved cropping and soil management practices. These have been fostered by education and incentive-based voluntary government programs. Moreover, U.S. farmers are less reliant on chemicals and fertilizers than farmers in other industrial countries, and have ceased expanding their use of chemical inputs. In addition, U.S. agriculture has become less energy intensive.

During the past several years, major farm bills have incorporated programs to address soil erosion and other problems confronting farmers, including: the swamp and sod buster programs; the conservation reserve; the conservation compliance provisions; the water quality improvement plan; and the integrated crop management program. All of these have helped make U.S. agricultural practices even more environmentally sustainable.

Farmers Are Good Stewards

The image sometimes presented of U.S. agriculture as an egregious abuser of its natural resource base — and as a voracious user of chemicals and energy — is highly misleading. In fact, farmers' claims of good stewardship of natural resources stand up quite well. This is not to say that no environmental problems exist, or that no further government intervention is required. Rather, it is to ask: to what lengths should regulatory policies go? at what costs? and for which benefit?

Agriculture's regulatory agenda is complex, but the primary environmental and food safety goals are clear: cleaner water and air; soil conservation; a safer food supply; wildlife and habitat protection; and safety of farm workers. Legislation to address these goals include the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA); the Clean Water Act; the Endangered Species Act; the Delaney Clause of the Food, Drug and Cosmetic Act; the Nutrition Labeling and Education Act; and biotechnology regulations. All will directly affect U.S. agriculture.

To make rational regulatory decisions, it is important to quantify the effects that regulatory options may have on farmers, as well as consumers, taxpayers, rural residents, and agribusiness. In undertaking such a task, this report outlines qualitatively the prospective actions and consequences of proposed regulations. It reviews analytical work that impacts on proposed regulations and synthesizes these analyses as an aid to rational decision-making.

Regulations Impact Consumers, Rural Communities and the Environment

The analytical studies of chemical use regulation assume a range of policies, from a slight reduction to a complete elimination of chemicals or pesticides. While there is some variability in estimated costs, the estimates are all quite large under a variety of assumptions and approaches. The studies also agree on another point: U.S. consumers would pay a large part of the costs of chemical restrictions in the form of higher food prices, with a disproportionate share of the cost falling on low income families. The studies also point to strong, adverse impacts on regions and rural communities affected by particular regulations.

It is more difficult to estimate the economic consequences of tighter biotechnology regulations because such regulations delay or prevent innovations that could otherwise occur. While precise estimates are very conjectural, each year that innovations are delayed from commercial adoption, billions of dollars in productivity gains are lost. Slower productivity growth may mean greater stress on the environment as farmers use more resources to meet world food needs.

Over-regulating biotechnology also carries the threat of undermining an innovative approach to improving the environment. Stiffer EPA regulations for approving pesticides are delaying the introduction of chemicals that are environmentally preferable to the ones they replace.

Aggregated Impacts

It is unlikely that Congress would take a draconian step like banning all pesticides or all biotechnology. However, it is entirely likely that Congress might approve more limited, but still significant regulatory changes that would have a large cumulative impact on the agricultural sector. What might be the consequences of such a regulatory blanket thrown over U.S. agriculture? It is possible that such regulations might reduce fertilizer use by 20 percent; pesticides by 30 percent; land in crops by 5 percent; while delaying the commercialization of biotechnology, and raising costs through labelling requirements, licensing, and worker safety regulations. These changes all move agriculture in the same direction — placing pressure on our cropland base, raising production costs, reducing exports, and increasing food prices, while reducing asset values and draining economic activity from rural areas.

As regulation proceeds simultaneously in many areas, economic impacts can be compounded. Effects of chemical restrictions, for example, can be moderated by farmers' ability to substitute land and labor for chemicals. But when wildlife protection and soil conservation programs are coupled with chemical restrictions, the economic effects of the whole are larger than the sum of the component programs.

Consequences of Regulations

Based on the analysis in this study, the consequences for U.S. agriculture of combined regulatory actions outlined above include:

- Consumer food cost increases of $10 to $20 billion annually, or $250 per household, with the heaviest burden falling on lower income families.

- Net farm income losses ranging from negligible to several billion dollars. The problem is exacerbated because farmers in some regions will suffer disproportionately.

- Falling farm asset values, especially in areas where endangered species recovery plans or pesticide reductions hit hardest. Together with income losses, falling asset values would force many farmers out of business.

- Job losses in environmentally sensitive rural areas, with a commensurate loss in the rural tax base and general economic vitality.

- Mixed, but predominantly negative, impacts on agribusinesses due to the overall decline in farm output.

- Export declines of 20 to 30 percent, or roughly $10 billion annually, creating the opportunity for U.S. competitors to expand their food and fiber production capacity.

Given such large costs to society of increased environmental and food safety regulations, what are the benefits? The benefits of enhancing water quality by regulating agricultural production are not well established. And while some studies show substantial benefits from the conservation reserve and conservation compliance programs, it is not clear if the benefits exceed the costs. Similarly, evidence on the health and food safety benefits of tighter regulations on farm inputs is weak. Lastly, while efforts to save endangered species are undoubtedly valuable, we have no measures of whether the public benefits will outweigh the public and private costs.

The substantial potential costs of legislative and regulatory actions on environmental issues to U.S. agriculture, including farmers, agribusinesses, and rural communities, require that such actions be carefully considered to minimize their effects on farm costs, while ensuring the desired environmental and food safety benefits.

Possible Approaches

The potentially large costs of environmental regulations — and the uncertainty of benefits — requires policymakers to pay close attention to the choice of regulatory mechanisms. Four possible approaches include: mandated practices, taxes and fees, environmental targets, and market-based incentive programs. None is a panacea. Each involves trade-offs. The hard truth is that under any method of implementation, large costs are inevitable. The economic risks of overly rigid regulations and the uncertainty of benefits argues for development of workable, information-based voluntary approaches rather than regulatory mandates.

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I. The U.S. Agricultural Economy

An accurate assessment of legislation that might affect regulation of agriculture requires an accurate assessment of the strengths and vulnerabilities of the U.S. agricultural economy. U.S. agriculture's situation is complicated because it combines economic strength and dynamism with the fragile financial condition of many farms and related businesses, such as rural banks. Throughout its history, the U.S. has been a low-cost producer of agricultural products. Consumers have benefited from a continual decline in real farm commodity prices, coupled with food expenditures being a declining percentage of consumers' total budget (Figure 1).

The U.S. position in the world economy has been strengthened by the nation's role as a food exporter. This is due to an abundant supply of arable land, and the early and intensive application of science and technology to agricultural production. As the data of Table 1 indicate, the U.S. has become the world's primary source of food products in both ongoing commercial trade and in providing food assistance in times of emergency. The U.S. has 4.7 percent of the world's population, but 13 percent of the world's cropland. With these resources, U.S. farmers produce 19 percent of the world's cereals, supply 15 percent of the world's food imports, and provide over 55 percent of all international food aid in cereals.

At the same time, many U.S. farmers have been under chronic financial pressure, and sector-wide financial crises have periodically struck farming and related businesses. Financial pressures result primarily from the combination of technological progress and intense competition in farming and agribusiness. Farmers tend to expand output whenever cost reductions or temporarily favorable market conditions generate profits, thus reducing commodity prices.

Figure 1.

FOOD'S SHARE OF CONSUMERS' BUDGET FALLS, WHILE REAL FOOD PRICES REMAIN STEADY

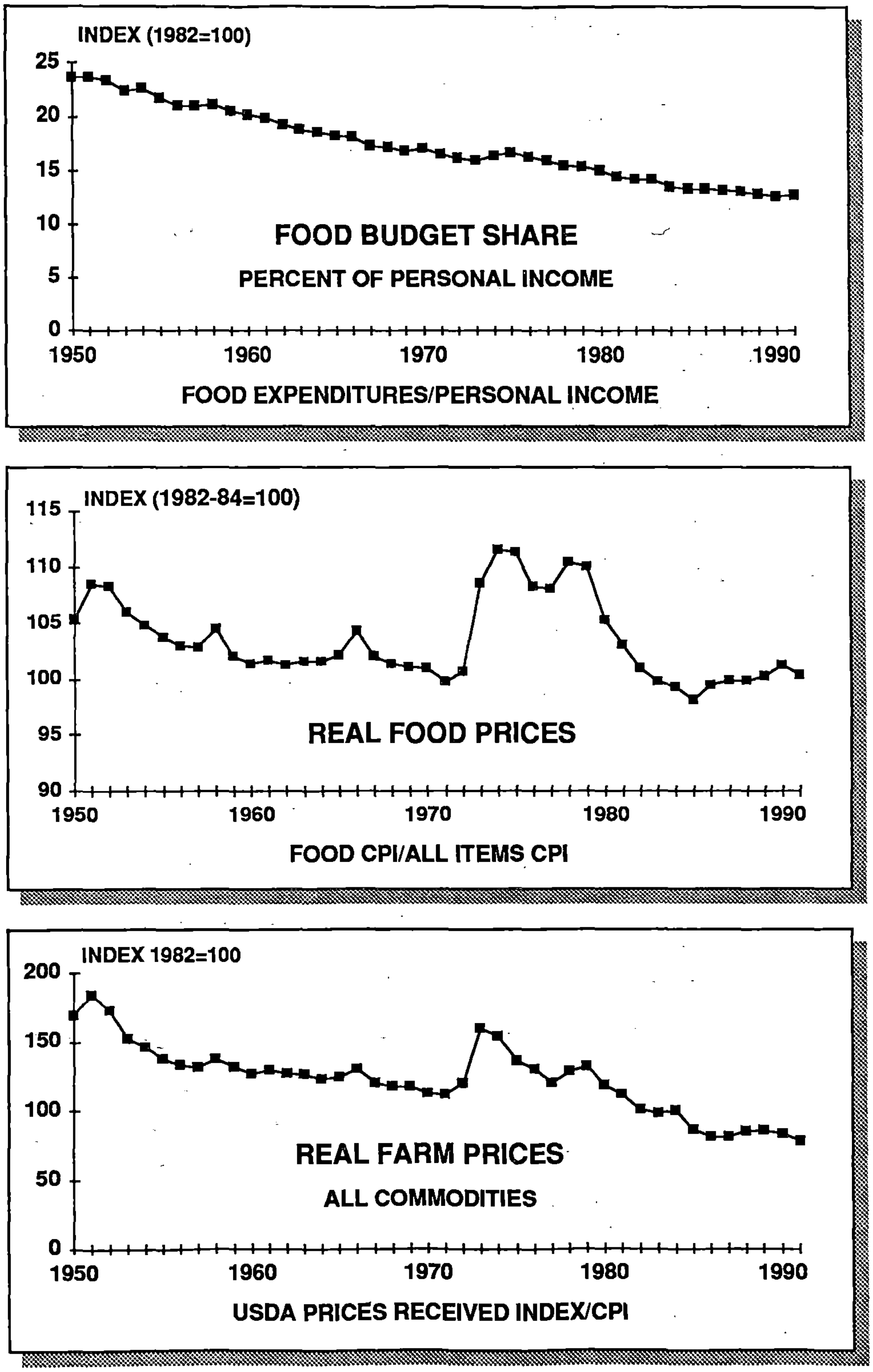


Table 1. The United States in World Agriculture

	World Total	U.S.	U.S. Share of World (%)	U.S. Rank
Population, 1990 (millions)	5289	250	4.7	4
Cropland, 1987 (million hectares)	1474	190	13	2
Agricultural Output, 1989 (billion $)	1092	150	14	2
Cereal Production, 1989 (million tons)	1870	284	19	1
Wheat	540	55	10	2
Rice	508	7	1	11
Corn	472	191	40	1
Other Feed Grains	270	30	11	3
Total Oilseeds	206	59	29	1
Soybeans	107	52	49	1
Cotton (lint)	17.5	2.7	15	2
Total Meat	168	28	17	1*
Beef	50	11	22	1
Pork	67	7	10	2
Poultry	37	10	27	1
Food Aid Contributions (cereals), 1991/92 (million tons)	12.4	7.0	56	1

Sources: USDA, Global Food Assessment and World Agriculture; World Resources Institute, World Resources; and The World Bank, World Development Report.

* Virtual tie with Former USSR (counted as 1 country for ranking purposes).

As a result, competitive pressures have passed the benefits of technological progress on to food and fiber consumers, and have maintained the U.S. as the world's leader in agricultural exports. At the same time, they have also created economic vulnerabilities.

In response to these vulnerabilities, the federal government has created a set of commodity policies which have provided assistance to farmers, but have not solved agriculture's complex problems. The most recent illustration was the "farm crisis" of the 1980s. In the 1970s, farmers expanded output in response to a boom in overseas demand for U.S. agricultural products. Many farmers borrowed heavily to purchase land and equipment. When the second oil price shock occurred in 1979, and the boom ended, farmers found themselves facing lower commodity prices, high interest rates on their debt, and rising costs for energy and other inputs. As a result, during 1980-83 real net farm income fell to about half the average level of the 1970s, and agricultural assets lost about a fourth of their value, declining by $220 billion (Figures 2 and 2a). The squeeze on farmers' ability to repay debt, coupled with declining land values, led to the farm crisis of the mid-1980s. Farm income has now recovered to pre-crisis levels, but land values remain below their 1981 peak, and residual concern about the economic health of agriculture persists.

The economic problems of the early 1980s diverted public attention from longer-term trends. These longer term trends reveal a major success story in both the international context and the domestic sphere:

- Productivity continues to grow at a rapid rate in agriculture, even as productivity in the nonfarm economy has lagged (Figure 3);
- Consumer costs of food products continue to hold steady and to constitute a smaller share of household expenses (Figure 1);
- The incomes of farm households continue to rise in real terms, and relative to nonfarm households (Figure 4);
- Agriculture continues to be competitive internationally, and to make a significant contribution to U.S. net export earnings (Figure 5).

Figure 2.

NET FARM INCOME HAS RECOVERED

REAL (1982 $)

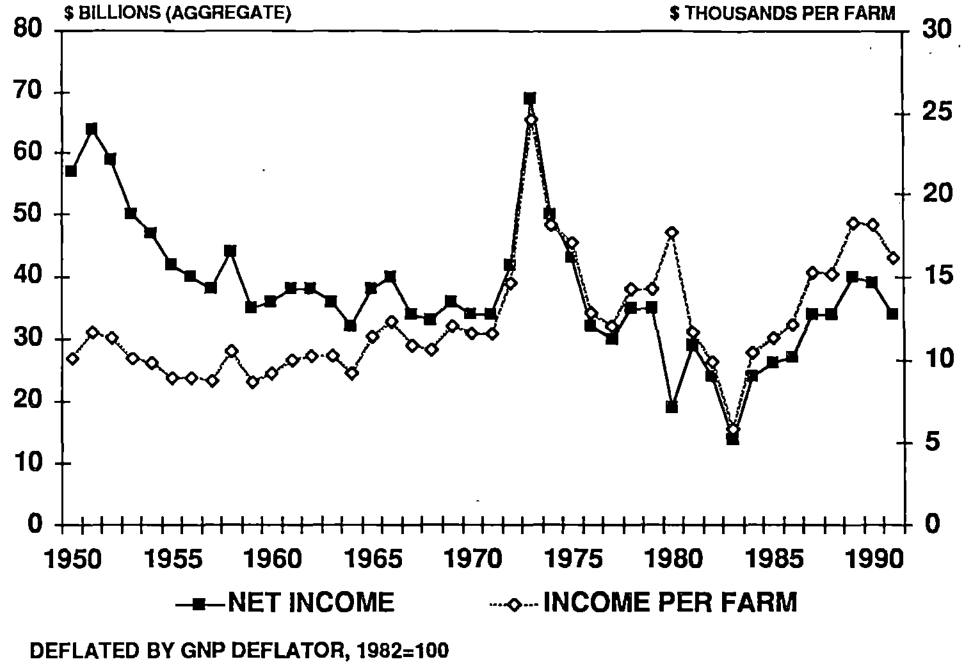


Figure 2a.

FARM ASSETS REMAIN BELOW PEAK VALUES

REAL ESTATE

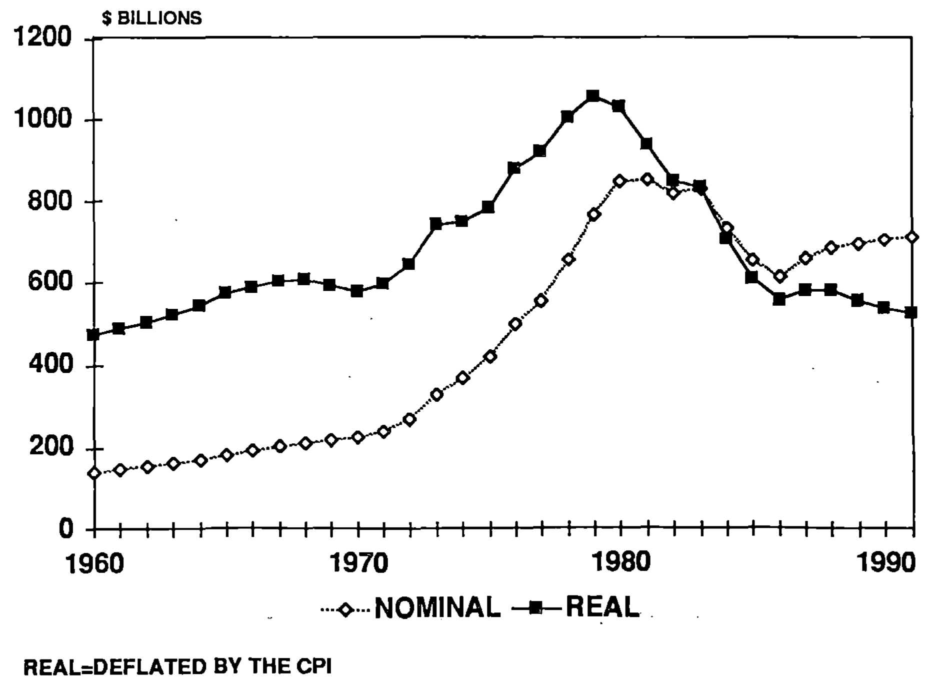
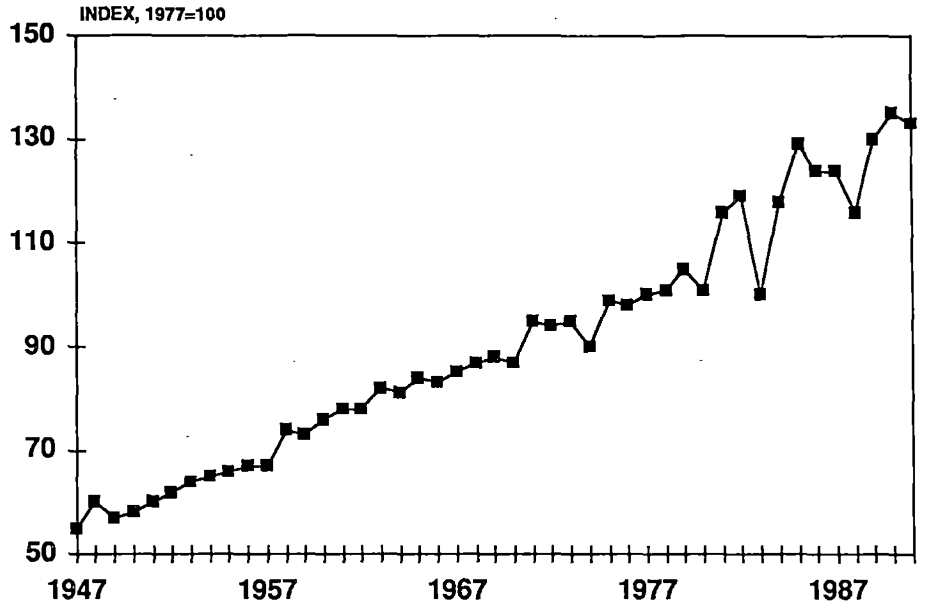


Figure 3.

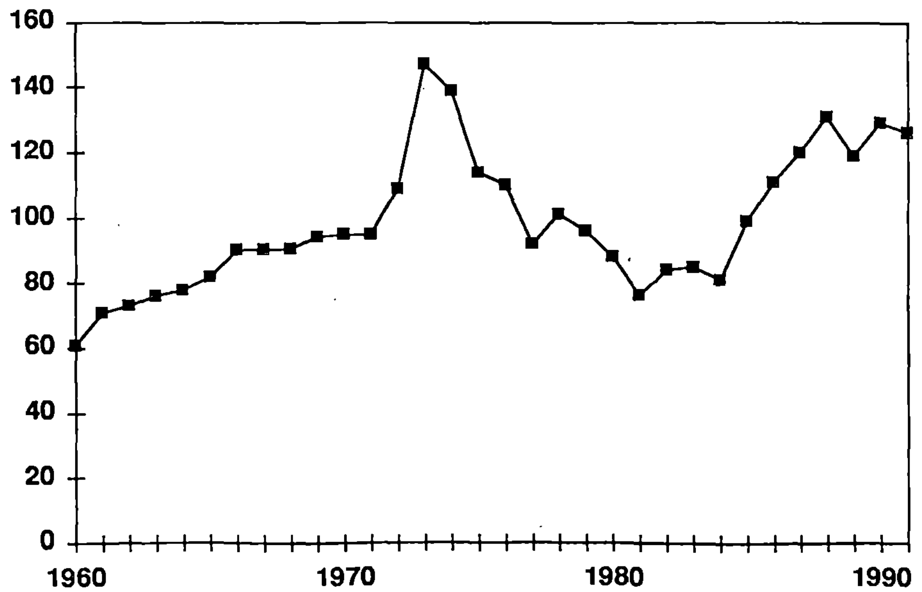
AGRICULTURAL PRODUCTIVITY CONTINUES TO RISE



OUTPUT PER UNIT OF TOTAL INPUTS

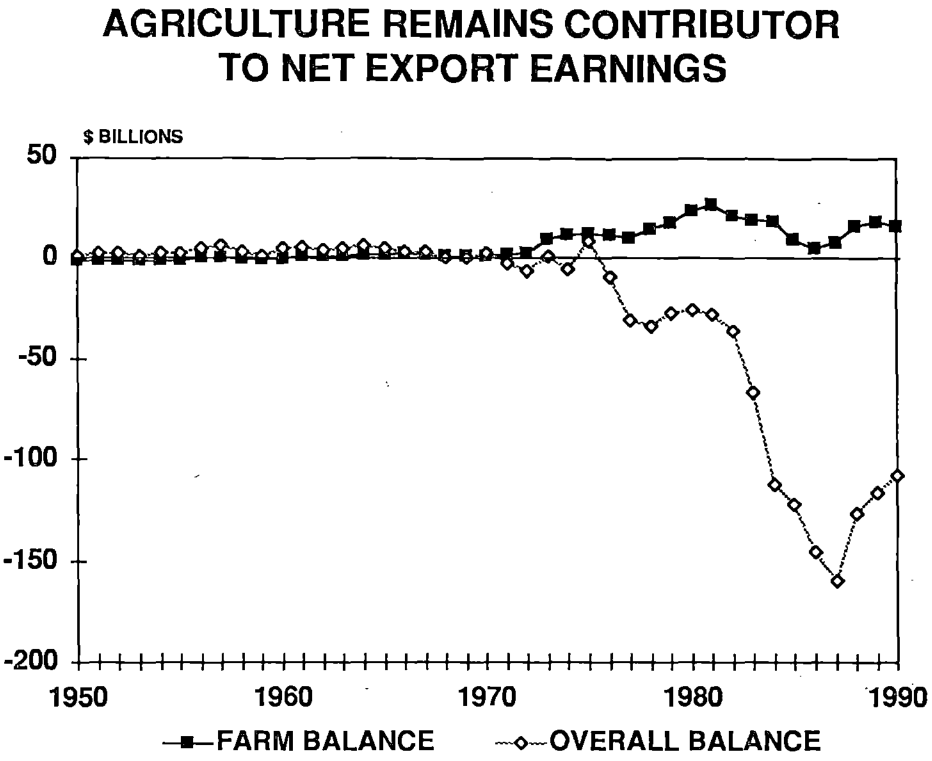
Figure 4.

FARMERS INCOME FROM ALL SOURCES HAS STRENGTHENED



RATIO OF INCOME IN FARM AS COMPARED TO NON-FARM HOUSEHOLDS

Figure 5.



OVERALL IS ALL MERCHANDISE

These trends are intricately linked. Most importantly, the continuing growth of productivity in the U.S. farm and food industry enables U.S. farmers to provide consumers with lower-cost food products while still increasing farm income. Continuing efficiency increases have maintained agricultural exports, even in the face of increased import protection and foreign export subsidies.

Productivity growth is the key to agriculture's future international competitiveness, and hence, to the prosperity of U.S. farmers. Unfortunately, past rigid commodity pricing policies have often made this virtue into a vice — rather than being viewed as a benefit. Additional output that could not be sold because of high price supports was seen as a burden. But farm commodity policies were fundamentally changed with the 1985 and 1990 farm legislation. These market-based reforms are likely to be maintained and even expanded. Budgetary pressures alone almost ensure a continued move away from costly, inflexible approaches to commodity policies.

The trend toward less reliance on farm programs need not have ill effects on farm incomes. In fact, farm income has held up well since the mid-1980s, even as budgetary outlays were reduced. Table 2 shows recent USDA projections for net cash income of farms compared with the previous seven years, and indicates farm income prospects have not declined appreciably despite the reduction in farm program outlays. Net cash income achieved record-high levels each year from 1988-90.

Table 2 also shows a significant recovery in net agricultural exports since 1987. In the economic situation of the 1990s and beyond, the main risk to farm income is reduced exports. The main risk to export competitiveness is losing the edge in controlling production costs. Moreover, the U.S. role as the world's predominant food producer — and the prospect for two

Table 2. Economic Indicators in Agriculture: Income and Trade Rebounded as Spending Dropped

Fiscal Year	Farm Program Spending	Net Cash Income of Farms*	Agricultural Trade Balance**
	---billion dollars---		
1985	17.7	47.1	11.5
1986	25.8	47.8	5.4
1987	22.4	55.8	7.2
1988	12.5	58.1	14.3
1989	10.5	58.9	18.1
1990	6.5	61.3	17.7
1991	10.1	58	15.0
1992	9.7	59	18.1

* Calendar Year
** Exports minus imports of agricultural products

Source: USDA, Agricultural Outlook, May 1993, Tables 26, 29, 34 billion more people to feed in the next 20 years — implies global food security risks if the U.S.does not maintain its growth in agricultural output. The World Bank estimates the world will need 3.6 billion tons of cereal grains annually by 2030, almost double the 1990 world production of 1.9 billion tons. Thus, for both national and global reasons, the primary source of concern about prospective regulation in pursuit of environmental and food safety goals is the potential threat to U.S. agricultural productivity and competiveness.

This concern is not just the worry of farm interest groups. The *Washington Post* recently reported on a General Accounting Office report concerning the reregistration of pesticides used on "minor" crops (a variety of fruits, vegetables, nuts, herbs, ornamentals, trees, and turf grass, adding up to about $30 billion annually in farm sales). The *Post* leads by stating: "Major problems may be looming for consumers and the farmers who grow 'minor' crops" (July 5, 1992, p. A15). The story questions whether some current and prospective pesticide policies are wise policy. A recent global study foresees increasing demand for U.S. farm products, but states that one of "four big reasons" why U.S. agriculture may not be in a position to reap benefits is "increasing concerns about food safety and the environment [leading to restrictions on production practices] that could hamper U.S. agriculture's future competitiveness" (Avery, p. 81). In a broader assessment of expert opinion, a recent survey of agricultural scientists and economists identified environmental quality concerns as the most important issue impacting the U.S. food and agriculture system in the next twenty years (Allen, 1993, pp. 4-5).

An assessment of the U.S. agricultural economy should include the environmental situation. On this subject, data are much less accurate and complete than production and economic statistics —indeed, an improved database for environmental assessment should be a governmental agenda priority. Some assessments have been carried out on groundwater quality, pesticide residues on food products, and soil erosion. Of these, soil erosion is the most detrimental because it is most pervasive and intense in its environmental consequences. In addition to reducing land productivity and silting waterways, soil particles are the main vehicle for transporting pesticides and fertilizers to streams, ponds and lakes.

The data available indicate that soil erosion is a less serious problem than in the past. Studies in the early 1950s estimated that three-fourths of U.S. cropland was eroding at a rate faster than the soil was regenerating (Lowdermilk, 1953). A more comprehensive survey in 1987 suggests that about one-fourth of U.S. cropland was eroding at that rate in the mid-1980s (Natural Resource Inventory, 1987). Numerous soil erosion assessments made since the 1930s indicate that substantial improvements have been made in reducing the rate of soil loss.[1] These improvements have come through improved cropping and soil management practices, fostered in part by educational efforts and voluntary government programs offering incentives to reduce erosion. Whatever the underlying causes, the evidence supports the view that stewardship of the land is an obligation that farmers already take seriously.

Water quality has been subject to recurrent problems due to bacterial and other pollutants from wildlife and human activity. Water quality problems caused by leached nitrates and pesticides are more recent concerns. In a recent nationwide survey of groundwater quality, EPA detected nitrates in the majority of sampled rural drinking water wells . Several pesticides showed up as well (EPA, 1990). EPA estimates 10.4 percent of community water system wells and 4.2 percent of rural domestic wells contain detectable levels of one or more pesticides (EPA, 1992, p. 5). However, only a small fraction of these concentrations exceeded drinking water standards, and no substantial health effects of chemicals in these wells have been established. This is in contrast to traditional problems such as the parasite in Milwaukee's water which caused illnesses and deaths in April, 1993.

U.S. farmers are less reliant on chemicals than farmers in other industrial countries, and have ceased expanding their use of these inputs. USDA's index of farm chemical use (fertilizers and pesticides) after a phenomenal rise between 1950 and 1980, has declined slightly in the last decade (Figure 6). Midwest data on corn insecticides indicate declines in use are not just a matter of reduced acreage, but that farmers are changing their practices (see Carlson, Garguilo

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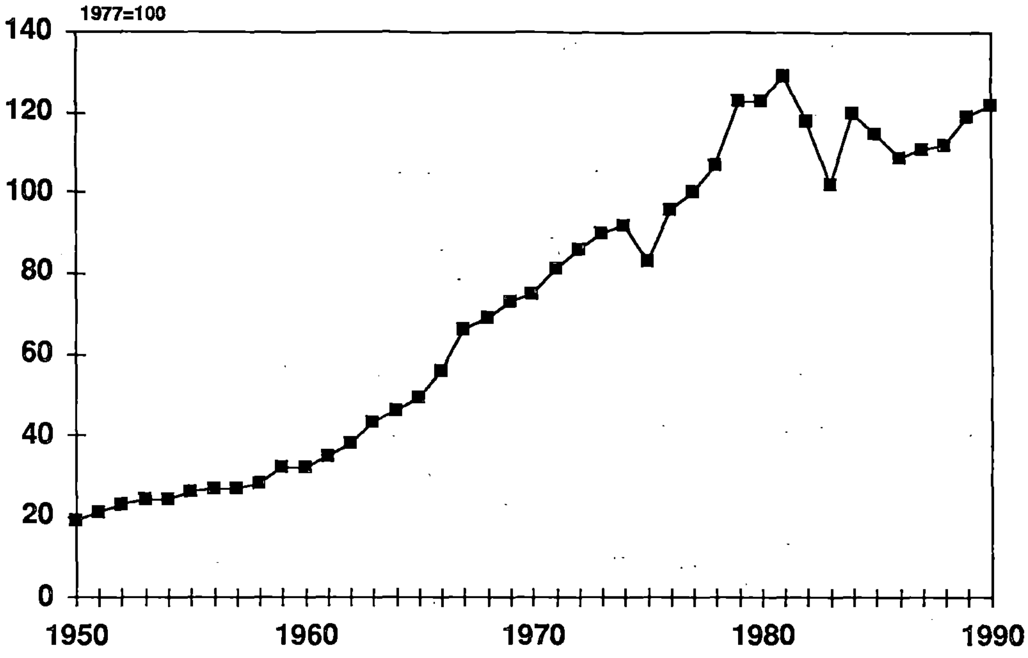
[1]For details, see Swanson and Heady (1984).

Figure 6.

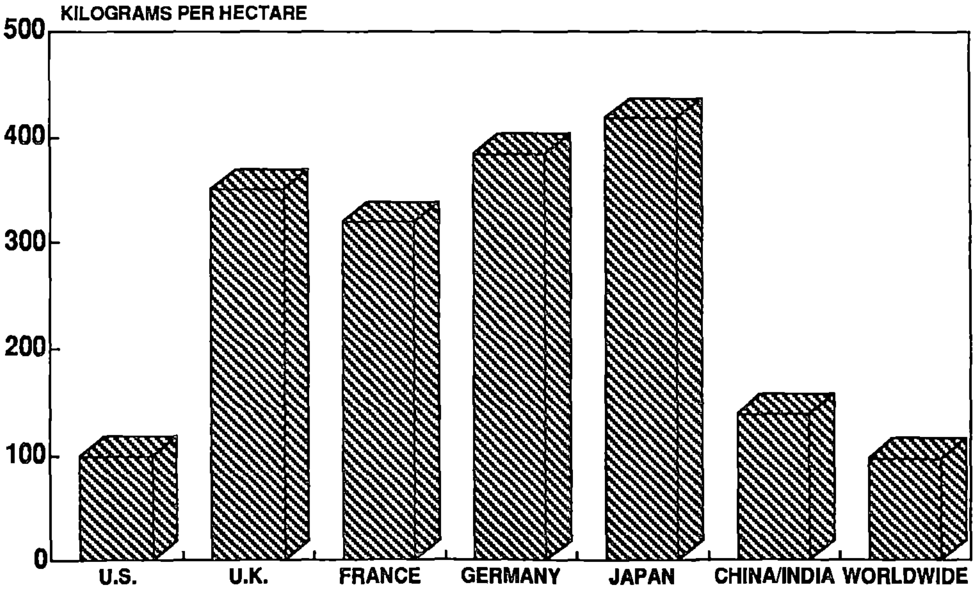
AGRICULTURAL CHEMICAL USE LEVELS OFF



PESTICIDES AND FERTILIZERS. SOURCE: USDA

Figure 7.

U.S. FERTILIZER USE WELL BELOW OTHER COUNTRIES



SOURCE: WORLD BANK

and Lin, 1993).

Data for comparison with other countries are most meaningful for fertilizer. Use of plant nutrients in 1989/90 is shown in Figure 7. The ratio of fertilizer use to arable land in the U.S. is well below other industrial countries.

In addition, U.S. agriculture has become less energy intensive. U.S. farm use of energy (predominantly petroleum fuels, electricity, and natural gas) has declined by 35 percent since 1974 (USDA, 1992, p. 27).

In short, the picture some have painted of U.S. agriculture as an exceptionally voracious user of chemicals and energy is highly misleading. Farmers' claims of good stewardship of their resources stand up quite well. This is not to say that no environmental problems exist in agriculture, or that no further government action is warranted. The importance of environmental goals and the legitimacy of governmental efforts to pursue them are not in question. The question is the lengths to which policies should go, their costs and the benefits that may be achieved. It is important to establish reasonable and responsible environmental standards, and to estimate as fully and rigorously as possible the costs of achieving these standards.

II. Commodity Programs and Regulatory Policy

The centerpiece of U.S. agricultural policy from the 1930s through the 1970s was a complex system of commodity price support programs. During their 60-year history, these programs evolved in commodity coverage and regulatory detail, but retained the use of three main policy instruments: loan rates, deficiency payments and supply control.

The U.S. government supports farm income for the major crops through loan rates and deficiency payments. Loan rates are essentially floor prices, which the government agrees to pay for a farmer's crop should market prices fall below the loan rate. Deficiency payments are paid to farmers based on the difference between the loan rate (or market price) and a higher, target price multiplied by a farmer's program acreage. Products covered under the target price/deficiency payment system include corn, other feed grains, wheat, cotton, and rice. Soybean growers receive a loan rate, but are not eligible to receive deficiency payments.

In many years, farmers have produced more output than could be marketed at the support levels. In those years, the Commodity Credit Corporation (CCC) has been obliged to purchase and store commodities. U.S. government outlays to acquire surplus stocks averaged around $8 billion (1982 dollars) annually in the 1950s — about 3 percent of federal government outlays, compared to about 1 percent today. CCC inventories averaged over $15 billion (Figure 8). In an effort to control these storage and acquisition costs, the government implemented supply control programs, such as the Soil Bank, paid land diversions, and mandatory acreage set-asides. More recent innovations have included the Payment-in-Kind Program, the Conservation Reserve, and the Whole Herd Buyout for dairy.

It became apparent during the 1980s that acreage idling was creating long-run problems as great as the short-run problems it solved. While U.S. acreage declined, other countries expanded their production, taking over markets the U.S. abandoned.

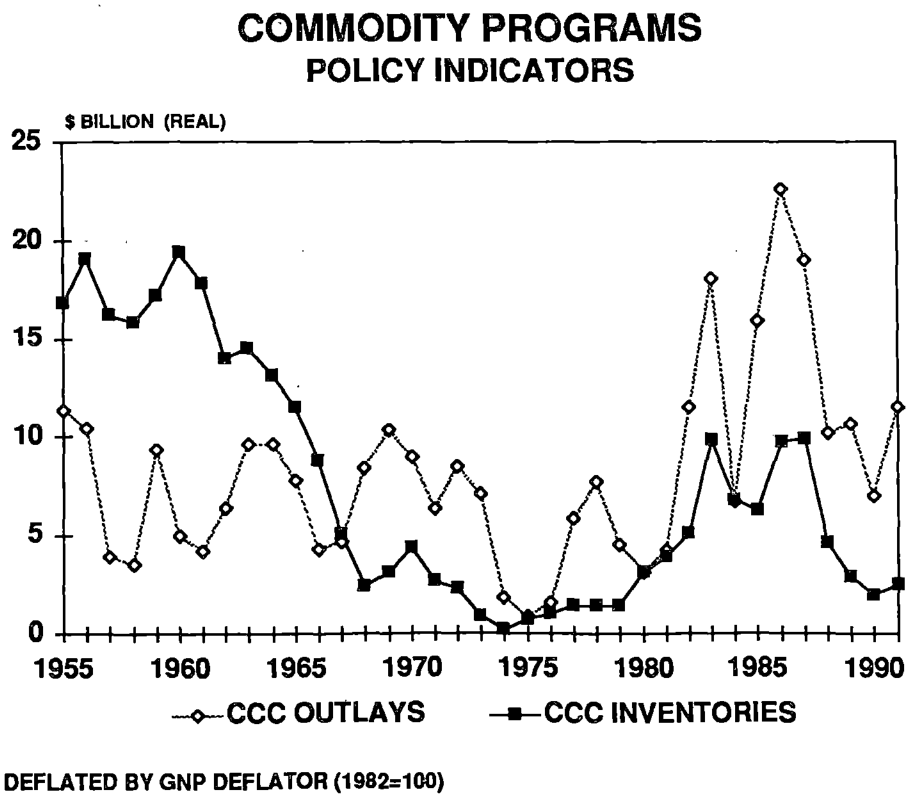
The Food Security Act of 1985 reversed these trends by establishing support prices that were geared to the market. This kept new surplus stocks from accumulating, an approach maintained in the Farm Act of 1990. The 1985 Act set the stage for the federal government to move away from commodity acquisition and storage, which reduced CCC outlays and stocks considerably by 1990 (Figure 8).

Substantial acreage controls still persist because deficiency payments to farmers promise to continue generating about $10-12 billion annually in CCC outlays. To control outlays, the Omnibus Budget Reconciliation Act of 1990 eliminated payments on 15 percent of farmers' program-crop acreage, reducing CCC outlays by about $1 billion annually. But with large Federal budget deficits still projected, pressure for further cuts will continue to be enormous. Virtually every deficit reduction plan includes additional reductions in farm program spending.

Commodity Policies and Conservation

Supply management opened the door to governmental regulation of farming practices. From its inception, supply management has been linked to soil conservation. In part, this linkage is accidental. When the Supreme Court ruled the first New Deal production controls unconstitutional, it left the door open for acreage controls based on soil conservation.

Figure 8.



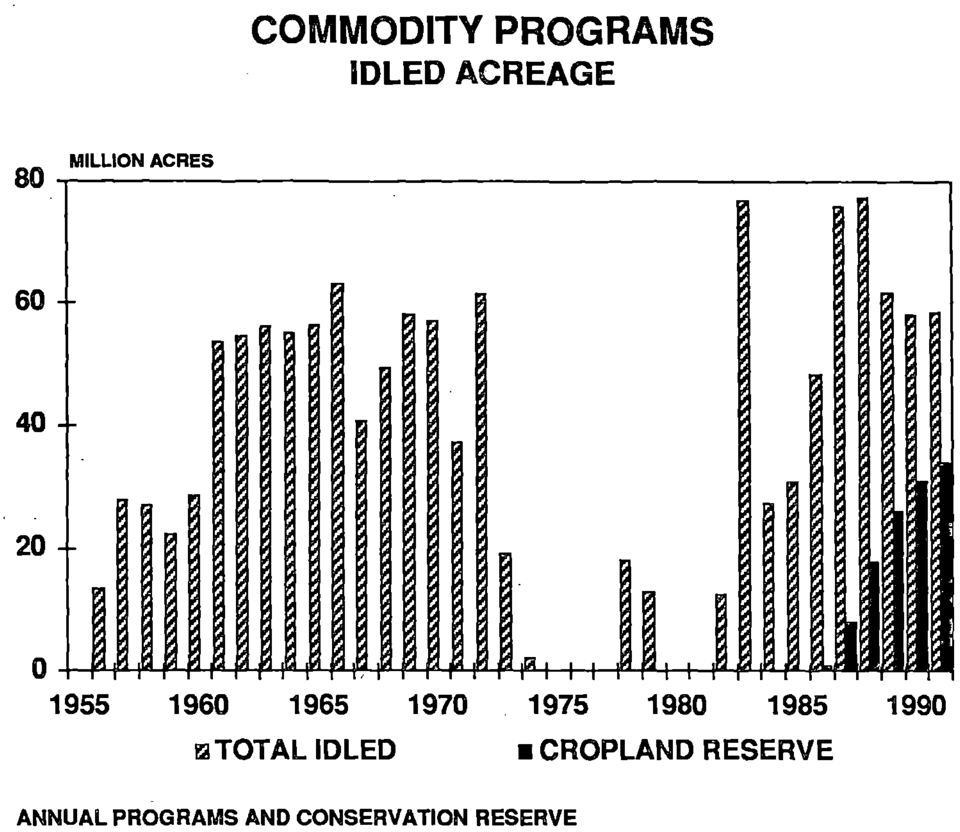
Subsequent legislation followed this path by generally linking conservation and supply management as joint goals of acreage idling programs. However, the rationale shifted over time to a political one — wider political support exists for programs which cause farmers to undertake environmentally beneficial activities in exchange for commodity program benefits.

This joint price-support and environmental approach received new impetus in the 1985 Act with introduction of the Conservation Reserve Program. By 1990, this program had enrolled 34 million acres of highly erodible cropland in 10-year contracts, paying farmers an average of $50 per acre each year. Participating farmers receive about $1.7 billion annually in rental payments, and about $100 million annually in federal cost-sharing for establishing soil conserving cover crops. In exchange, they agree not to grow marketed crops or to pasture the contracted acreage. With 10 percent of the nation's wheat and corn acreage base in the reserve, the program has been attractive because it conserves soil, while helping reduce surplus production and supporting farm income.

Some have argued that the program paid too much for the reduced soil erosion or commodity supply control results achieved (Reichelderfer and Boggess, 1988), leading to more precise environmental targeting in the 1990 Act. Since the 1990 program revisions, two and one-half million additional acres have been enrolled in 1991 and 1992, bringing the total Conservation Reserve to 36.5 million acres (see Figure 9). The 1990 Act authorized a further 4.5 million acres to be added to the reserve. But at $63 per acre (the average cost of the June 1992 contracts), the ten-year cost of further expansion would be $2.8 billion. This makes the program a likely target in upcoming budgetary debates. Moreover, since signing the first 10-year contracts in 1986, decisions must now be made by 1995 about: 1) extending the program (at great cost to taxpayers), 2) letting the land return to crops (giving back soil erosion gains), or 3) mandating that farmers continue conservation practices (at substantial cost to farmers).

High costs of the Conservation Reserve have led to policies requiring farmers to improve soil erosion without additional compensation. The highly erodible land conservation ("sodbuster") provisions of the 1985 Act deny federal agricultural program benefits to any

Figure 9.



person who "produces a crop of an agricultural commodity" on highly erodible land without following an approved soil conservation plan.[2] The sodbuster provision was aimed at limiting conversion of an estimated 70 million acres of grassland or forests to cropland.

To deal with erosion problems on land that had been cultivated prior to enactment of the 1985 Act, a "conservation compliance" provision was established. Under the 1985 Act, any farmer who produces an agricultural commodity on highly erodible land must use appropriate conservation practices determined by USDA's Soil Conservation Service, as a condition of eligibility for commodity price support and other federal benefits. The determination of both "highly erodible" and "appropriate" conservation practices is difficult, and requires arbitrary

[2]Land that had been cultivated in any of the 5 previous growing seasons was exempted from the provision. Also, because loss of many thousands of dollars in benefits for minor violations seemed unfair, and because of concern about lax enforcement without additional flexibility, the 1990 Farm Act established a schedule of graduated penalties of $500 to $5000 (depending on the severity of the violation) for inadvertent, minor or technical violations, with only one such violation allowed in any 5 year period.

regulatory decisions. Contention over details and burdens on farmers caused delays, but, the plan had to be in place as of December 31, 1989. As of 1995, production on over 100 million acres of highly erodible land will be covered. Farmers not actively applying all provisions of the conservation plan (some will be phased in over the 5 year period) will be ineligible for many agricultural program benefits.

Conservation compliance requirements have reinforced current trends, resulting in an impressive increase in the use of conservation practices such as windstripping, no-till cropping, and crop residue maintenance. The Center for Resource Economics carried out a review documenting several dramatic changes. They cite the expansion of no-till cotton in Terry Country, Texas, from 200 acres in 1989 to 35,000 acres in 1992, as an example (Cook and Art, 1993, p. 36).

Traditional interest in soil conservation has broadened to other environmental concerns, notably intensified efforts to restrict development of wetlands. Wetlands protection ("swampbuster") was added to the 1985 Farm Act to discourage the draining and cultivation of wetlands that are unsuitable for agricultural production in their natural state. The draining and planting of crops for harvest on wetlands causes ineligibility for various farm program benefits.

As of 1992, USDA had found 1,953 producers to be in violation of conservation compliance, sodbuster, and swampbuster requirements. As a result, $10.8 million in program benefits were denied to these producers (Cook and Art, p. 10). However, $4.6 million was restored on appeal.

Water quality is addressed in new ways in the 1990 Farm Act. Criteria for accepting farmers' bids in the Conservation Reserve Program were refocused, and a new Water Quality Improvement Program, a new Wetlands Reserve Program, and a new Integrated Crop Management Program were established. The new programs, especially Water Quality Improvement and Wetlands Reserve, require appropriated funds for payments to farmers. Appropriations have been too limited in the first two years of the 1990 Act for these programs to have any significant impact. During the first Wetland Reserve signup in July, 1992, farmers filed intentions to participate on nearly half a million acres. However, the $46.4 million appropriation permitted only 50,000 acres to be accepted. For FY1994, the cap was raised to 75,000 acres.

The 1985 and 1990 farm legislation also created research and outreach programs in "sustainable" production practices. These were intended to reduce the use of conventional inputs, to develop agricultural raw materials as substitutes for fossils fuels, and to provide incentives for marketing of food products with greater attention to pesticide residues. USDA's Agricultural Research Service and other USDA agencies have substantially increased their spending in these areas.

Anti-Environmental Features of Price Supports

While acreage idling and soil conservation have been seen mostly as complementary activities, critics have pointed to farm programs that work against environmental goals. In general, price supports encourage farmers to produce more than they otherwise would, using more fertilizers and other chemicals than market conditions warrant. Acreage controls, by limiting farmers' land area, can intensify the incentive to boost yields on the remaining planted acres. The crops with the strictest acreage controls, tobacco and peanuts, experienced tremendous yield increases in the 1950s and 1960s, until output quotas replaced acreage allotments as the primary supply control instrument.

Even without acreage controls, price supports can increase the use of purchased inputs to boost yields. For example, the European Community has supported wheat prices at roughly twice the U.S. price. This has fostered the high EC fertilizer use reported earlier, and European yields that are three to four times U.S. wheat yields. These high yields are attained principally by multiple application of chemical fertilizers in a climate favorable for their use. Several studies indicate that use of fertilizer and other purchased inputs in the U.S. has been artificially encouraged by U.S. price support programs.[3]

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[3]See, Hertel, Tsigas, and Preckel (1990), Helmers and Wehrman (1992), Carlson and Shui (1992), and Helmers, Spilker, Azzam, and Freisen.

Concerns (more budgetary than environmental) about effects of U.S. farm programs on yields led to a freeze on "program yields" in the Food Security Act of 1985. Prior to 1985, a farmer could obtain increased deficiency payments by increasing the farm's yield per acre and establishing a "program yield" at a higher level. Fixing, or "freezing" this yield removes the farmer's incentive to add fertilizer or other inputs in order to receive higher payments on the farm's eligible acreage. Despite political pressure to unfreeze program yields in 1989 and 1990, the freeze was extended in the 1990 Farm Act. This was due mainly to the increase in budgetary outlays that would be caused by unfreezing program yields. Allowing program yields to rise would have increased total deficiency payments, thus undoing the savings in outlays that had been accomplished with the reduction in payment acres. In addition, there is evidence that freezing program yields has environmental benefits (see Hertel, Tsigas, and Preckel, 1990).

Environmental and Food Safety Regulation Beyond Commodity Programs

Legislation aimed at assuring food quality and safety is not new. The major legislation, the Federal Food, Drug and Cosmetic Act, became law in 1906, many years before agricultural commodity programs were established. The Packers and Stockyards Act and meat grading and inspection programs under the Agricultural Marketing Service (AMS) and Food Safety and Inspection Service (FSIS) are of a similar age. The "Delaney Clause," which bans the use of any food additive found to cause cancer in animal feeding tests, dates back to the Food, Drug and Cosmetic Act Amendments of 1958.

The legislative and regulatory agenda has expanded steadily, and at an accelerating rate, since the 1960s. The rise of this agenda can be seen in the inclusion of non-commodity provisions in farm legislation during the past 15 years. Table 3 indicates the expansion of the environmental/food regulation agenda by simply listing the titles of relevant sections of these laws.

What these headings do not indicate is the move away from rewarding farmers for voluntarily engaging in desired activities, toward penalizing farmers if they do not. In view of the large sums spent on farm programs, some argue that farmers ought to be undertaking environmental improvements in exchange for commodity program benefits.

Table 3. Environmental/Food Titles of Recent Farm Legislation

1977 Act	1981 Act	1985 Act	1990 Act
XIV. Research, Extension and Teaching: Subtitle H, Solar Energy; Subtitle J, Sec. 1461, Organic Farming Study XV. Rural Development and Conservation	VII. Research Extension and Teaching: Sec. 1434-35, Solar Energy XV. Resource Conservation	XII. Resource Conservation: Subtitles A-C. Conservation of Highly Erodible Lands and Wetlands; Water Resource Conservation XIV. Research Extension and Teaching: Sec. 1410, "High Priority" to biotechnology and conservation research; Sec. 1444, Pesticide Resistance Study	XII. Subtitle C, Tree Planting XIII. Subtitle C, Cosmetic Appearance XIV. Subtitles A-H, Highly Erodible and Wetland Conservation; Environmental Quality Council; Water Quality; Pesticide Recordkeeping; Composting Research XVI. Research. Subtitle B, Sustainable Agriculture; Subtitle G, Alternative Agricultural Research; Subtitle H, Sec. 1668, Biotechnology Risk Assessment Title XXI. Organic Certification Title XXIV. Global Climate Change

Some intensely debated issues involve wetlands. Beyond the swampbuster provision discussed earlier, the Clean Water Act requires a permit from the Army Corps of Engineers for a broad range of farmers' projects, including drainage and land improvement. Wetland drainage is not to be permitted unless stringent steps are taken to minimize the effects and mitigate the consequences. Drainage carried out in violation of the Clean Water Act causes penalties in fines and restoration costs that go well beyond swampbuster provisions discussed earlier. Many in the farm community see the Clean Water Act as unfairly restrictive and even confiscatory regulation of their activities. Cases in which violators of the Clean Water Act (or swampbuster) have received seemingly harsh penalties for minor or inadvertent violations have been highly publicized and are *causes célèbres* in rural areas.

In addition, the Clean Water Act, the Endangered Species Act, and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), regulate when and where pesticides may be used, precautions that must be taken against drift of sprayed pesticides, training of pesticide applicators, and reentry of farm workers into fields after pesticide applications. It also bans the use of some chemicals. Other initiatives on pesticides -- sustainable agriculture, cosmetic standards, grain quality, and standards for "organic" foods -- are being pursued with research studies and draft regulations required under the 1990 Farm Act. Experience with these initiatives will influence the future of regulatory policy in agriculture. The effects of current implementation efforts are still uncertain.

Two environmental organizations have recently completed studies indicating directions in which the policy debate is likely to move. The World Resources Institute argues that commodity programs, epitomized by the corn program, have discouraged conservation, and have induced farmers to undertake environmentally damaging practices (Faeth, et al., 1991). The report states: "Commodity programs that penalize resource-consuming rotations are causing farmers to jeopardize their future income by allowing soils to erode, groundwater to be contaminated, wildlife to be poisoned, and reservoirs to silt up" (Faeth et al., p. vii). This is a generalization of the earlier discussion of the yield effects of commodity programs. Even with frozen yields, the programs encourage farmers to maintain yield levels attained in the early 1980s, and to maintain their crop acreage base. The importance of the claims made in Faeth et al. is not established, and the claims are inherently dubious insofar as they assume farmers shortsightedly reduce their own future incomes. Some counter-evidence has been marshalled by Carlson, Garguilo, and Lin (1993). But to some extent, this concern does seem to be having an impact in farm policy debates.

The Center for Resource Economics has recently followed a different line of inquiry, assessing the effectiveness of environmentally oriented provisions of the 1985 and 1990 Farm Acts. The Center's authors are very critical of the implementation of these provisions. With respect to conservation compliance they state: "we question USDA's resolve to implement the policy, the effectiveness of its monitoring and enforcement, and the veracity of its claims that only a tiny fraction of farmers failed to actively apply conservation compliance plans in 1991" (Cook et al., 1992, p. 1). In a follow-up study, the authors state: "it is highly probable that in 1992 as in 1991, tens of thousands of farmers received hundreds of dollars in farm program benefits for which they should not have been eligible because they were not complying with sodbuster, swampbuster, or conservation compliance" (Cook and Art, 1993, p. 1).

These views indicate an impetus toward two important regulatory changes: further weakening (abetted by budgetary pressures) of the economic attractiveness to farmers of traditional commodity programs, and tougher enforcement of environmental regulation of farming. These forces could make the time between now and the passage of the next omnibus farm bill an especially contentious period in policy formation.

In addition to their role in domestic policy debate, environmental issues have entered international debate on bringing down trade barriers in farm commodities in the Uruguay Round of General Agreement on Tariffs and Trade (GATT) negotiations and the North American Free Trade Agreement (NAFTA). Environmental issues are potent in these negotiations because of the tendency of protectionist interests to use any arguments available, including claims that imported products are substandard or are produced in ways that harm the global environment. At the same time, all sides agree that nations have a right to genuine health and safety standards. Lax environmental standards in competing nations may sometimes be legitimately viewed as a de facto export subsidy.

Summary

Commodity price support programs are an attractive point of departure for broader regulation of agriculture. From the beginning, price supports have led to the control of farming practices, particularly of land use. These controls can easily be structured to pursue goals other than price support. The key trends in U.S. commodity programs are:

- Budgetary pressures leading to fewer and more targeted benefits for farmers from traditional commodity programs;
- International competition forcing the U.S. toward less production control, continued market-clearing support prices, and reduced barriers to imported farm products;
- Environmental pressures requiring farmers to undertake additional measures to promote water quality, to protect endangered species, to conserve soil, and to promote other environmental goals in exchange for commodity program benefits.

Together, these trends will make the commodity programs far less attractive to farmers, and hence, will significantly reduce program participation. A consequence is that political forces for environmental improvement will be increasingly shifted toward direct regulation of farm practices, as well as commodity programs.

III. The Regulatory Policy Agenda for 1993/94

The federal regulatory agenda for agriculture is important in 1993/94 because the main environmental laws affecting agriculture — the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Clean Water Act, and the Endangered Species Act — are up for Congressional reauthorization. In addition, regulatory scrutiny of biotechnology will intensify. New regulations under the Coastal Zone Management Act may have significant effects in 29 states, and may set a pattern for EPA in promulgating nationwide regulations in a reauthorized Clean Water Act. Beyond the federal agenda, a variety of evolving state and local regulations will target wastes from livestock enterprises, land use in suburban areas, pesticide and fertilizer use, water for irrigation, health and safety inspections for dairy, and even regulation of noise and odors.

The federal regulatory agenda, to which this study is limited, is so complex and replete with program details that it is a substantial undertaking simply to obtain a coherent picture of prospective actions. It is also a matter of political guesswork. Given these complexities and uncertainties, it is helpful to begin by sorting the most salient issues according to goals sought, and objectives of each regulatory component.

The primary goals are: cleaner water, purer air, soil conservation, fewer health risks in food consumption, wildlife (particularly endangered species) and habitat protection, long-term sustainability of farm production, and safety of farm workers. Table 4 provides a tabular summary of goals and policies enacted or proposed to achieve those goals. The top row lists the goals just mentioned. Under each goal, Table 4 denotes by an "X" the set of policy instruments that have been or are seriously proposed for pursuing the goal. These instruments are broadly defined and are not always related to a particular piece of legislation. For example, the upper left-hand "X" identifies pesticide regulation as a policy used to promote clean water. But there are several different laws and regulatory policies covered by this entry. FIFRA gives EPA authority to ban uses of pesticides that would expose humans to significant health and safety risks. The 1990 Farm Act requires farmers to keep records of pesticide use. The Re-

Table 4. Environmental Goals and Policy Instruments Intended to Affect Agriculture*

		Goals (and principal legislation)						
		Water Quality (Clean Water Act)	Air Quality (Clean Air Act)	Soil Conservation (Farm Acts)	Endangered Species Protection (ESA)	Food Safety (Food, Drug and Cosmetic Act)	Worker Safety (FIFRA)	"Sustainable" Agricultural Production (Farm Act)
Policy Instruments	Pesticide Regulation	X	X		X	X	X	X
	Fertilizer Regulation	X			X		X	X
	Cropland Idling	X		X	X			
	Wetland Regulation	X			X			X
	Conservation Compliance	X		X				
	Biotechnology Regulation				X	X		X
	Agricultural Research	X	X	X		X		X
	Water (irrigation) Regulation	X			X			

*The X's indicate area regulated explicitly in an attempt to foster achievement of the goal at the top of the column. Regulation that affects the goals, but not as part of a program directly intended to attain the goal, has no X entry. For example, irrigation regulation may well affect soil conservation, but irrigation regulations are not an explicit component of soil conservation laws.

source Conservation and Recovery Act restricts what may be done with used pesticide containers whose residual contents might otherwise contaminate ground or surface water.

The entries in Table 4 denote only major, direct effects. Indirect consequences are more pervasive. Biotechnology will influence so many aspects of farm production methods, product mix, and costs that regulation will affect every environmental (and economic) goal. For example, new crops for alternative fuels, such as fast-growing sawgrasses, will change cropping patterns and hence affect soil erosion and water quality. These crops will also influence pesticide use, and affect all goals that pesticide regulation reaches. In short, a full accounting of direct and indirect effects of the policies listed would make Table 4 solid with X's.

The legislation that establishes these policies — and the framework for regulation under them — are elements of the agenda for action in 1993 and 1994. The remainder of this section describes these laws, how they fit in with the scheme of Table 4, and the main issues and actions surrounding them.

Clean Water

The Clean Water Act is the principal legislation aimed at improving water quality. Enacted in 1972, the current provisions that are most important for agriculture involve the regulation of wetlands, and of agricultural pollutants that enter groundwater and surface water (lakes, ponds, and streams) from eroded soils, fertilizers, pesticides, or livestock operations. Clean Water Act provisions could affect agriculture in several ways, but the main issue has been regulation of the use of wetlands.

Wetland policy is a "clean water" issue because plants that grow in wetlands can remove nitrogen, phosphorus, and other chemicals from water that runs off fields. Hence, wetlands help prevent these chemicals from contaminating drinking water or water used by wildlife. The determination of what constitutes a wetland, and under what circumstances wetlands may be drained and used for farming, has been controversial. After several years of wrangling within the Bush and Clinton Administrations, no changes were made in the wetlands delineation procedures established in 1987. Many in the agricultural community believe the current definition errs by classifying acreage as wetlands that is of little value for wildlife or other environmental purposes. The National Academy of Sciences has been directed by Congress to develop a wetland definition. The issue is certain to be revisited legislatively during the reauthorization of the Clean Water Act. Impetus was given to this issue when the Clinton Administration announced a new wetlands policy on August 24, 1993.

Beyond economic and environmental benefits and costs, the issue pits farmers' rights to place their land in the most economically advantageous use (or to be compensated for giving up that right) against environmental goals and the budgetary costs of compensation.

In a second regulatory area directly related to the main focus of the Clean Water Act, the 1993/94 reauthorization will likely attempt to regulate agricultural sources of pollutants, such as phosphorus, nitrogen, or leached pesticides. These and other "nonpoint" pollution — that which cannot be readily identified as coming from a particular location — are not now regulated by the Clean Water Act. "Point" sources, such as a city's sewage outlet or a factory's waste discharge pipe, have long been subject to EPA regulations on allowable emissions.

While nonpoint sources, such as runoff from fields or forests, have not been regulated by EPA, some states have taken substantive regulatory steps in agriculture in pursuit of water quality. Iowa has imposed a fertilizer tax to finance development and implementation of best management practices (BMPs) designed to reduce fertilizer and pesticide leaching into groundwater. Nebraska restricts pumping in areas with falling water tables or high nitrate concentration. Florida has imposed manure treatment requirements for dairy farms north of Lake Okeechobee. Phosphate runoff controls are being implemented for South Florida, including the idea of taxing landowners in the phosphate runoff area to finance purchase of catchment areas where vegetation could remove phosphates. This would prevent downstream areas near the Everglades from being affected by phosphate-rich water. The question is how the federal government will proceed in this area.

Farmers are concerned about costs that such measures impose upon them. Consumers are concerned about the safety of their drinking water. EPA's survey cited earlier indicates no problems that call urgently for federal regulation. Nevertheless, fears that groundwater quality may deteriorate are likely to intensify calls for regulatory attention in the Clean Water Act. Another avenue for regulatory action on groundwater quality is the Safe Drinking Water Act, which authorizes EPA to set standards for chemicals in drinking water, e.g., nitrate and pesticides.

More immediate regulatory action is imminent under the Coastal Zone Management

Act Amendments of 1990. This Act mandates state programs to control nonpoint water pollution sources. EPA is providing management guidance to states for these programs, which must be submitted to EPA for approval by July, 1995. In December, 1992, EPA published a Regulatory Impact Analysis (RIA) of measures recommended to the States. The RIA classifies agricultural management measures as a key regulatory area, and incorporates regulation of soil erosion, confined animal facilities, fertilizer and pesticide application to cropland, grazing management, and irrigation.

Protecting Species and Habitats

The Endangered Species Act is the nation's chief statute enacted to conserve endangered or threatened species and their ecosystems. The Act establishes a uniform process for designating a plant or animal that is threatened with extinction, protecting that species from further decline in its numbers, and formulating a "recovery" plan to increase its numbers to a viable population. At present, the Act protects about 750 species of plants and animals found in the U.S., plus another 530 species found only in other nations. In addition, some 950 species are candidates for inclusion because of substantial declines of population.[4]

Recent controversies pitting protection of the northern spotted owl's habitat against timbering activities have highlighted potential conflicts between environmental protection and human activities.[5] Many such potential conflicts find a forum for expression in the Endangered Species Act, which has been controversial since its passage in 1973. But recent controversies have been intensified by habitat protection decisions and the potential effects on privately owned and public lands.

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[4]EPA reviews candidate species continuously and the statistics change continuously. Of the candidate species, some 400 are considered "Category I," which means that EPA considers the information or data probably sufficient to support a listing as endangered or threatened, but the determination process has not been completed. An additional 3,000 species are in Category II, where some information indicates a possible listing as endangered or threatened.

[5]However, timber restrictions in the spotted owl habitat areas have predominantly involved legal action under the Forest Service Management Act.

The statute bases decisions on listing a species as endangered strictly on prospects for the species, not on costs to people. However, economic impact considerations are used to determine and define "critical habitat" necessary to ensure the survival of a species. In 1978, Congress established a Cabinet-level Endangered Species Committee (the so-called "God Squad"), which can waive restrictions imposed by the Act, and allow an activity (such as logging) to proceed, even if such activity is thought to imperil the existence of a species. This Committee was convened for the first time in 1992 in an attempt to resolve the northern spotted owl habitat question.

EPA's efforts to implement the Endangered Species Act via pesticide regulation illustrate how environmental and farm interests can collide.[6] The Act prohibits any action that places members or populations of an endangered species in jeopardy. These actions range from killing members of the species directly, to destroying their habitat or food sources. Pesticides can kill endangered plants or invertebrates living in fields, and they can destroy habitat. Pesticide drift into weedy border areas or streams can also kill members of endangered species or their food sources. For example, the snail kite (a hawk) that lives in Florida is on the Fish and Wildlife Service's list of endangered species. One of its main sources of food is the apple snail, which during dry periods migrates into drainage/irrigation canals, where both snails and kites can be exposed to pesticides. Thus, EPA could prohibit the use of any pesticide with known toxicity toward either snails or kites, or which has adverse effects on either snail or kite habitat.

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[6]EPA began to consider how to implement the Endangered Species Act in pesticide regulation in 1982. In 1986, it began circulating a proposal that would have banned the use of a number of pesticides in counties where listed endangered species were thought to be present. This plan caused a large outcry in the agricultural community. In 1988, Congress passed legislation prohibiting EPA from implementing its proposed regulations and requiring it to rethink its approach. In 1989, EPA developed a new approach in consultation with the National Agricultural Chemicals Association. It involves identification of areas within counties where endangered species are thought to be located, and restrictions on pesticides only in those specified areas. EPA has developed a set of county-specific pamphlets that describe areas in which pesticide use should be limited to protect endangered and threatened species from harm due to such use. The publications contain county maps showing the area within the county where pesticide use should be limited and a table of pesticide active ingredients indicating limitations by each ingredient.

Farm groups are pressing for reforms in the Act. The National Cattlemen's Association has adopted a policy urging Congress "to amend and revise the Endangered Species Act in a manner so as to provide balance, recognizing the need for economic benefit and the importance of private property rights..." (NCA 1992 Policy, p. 95). The American Farm Bureau Federation has also expressed great concern with the Endangered Species Act.

At the same time, environmental groups see the Endangered Species Act as a visible, well-known and broadly supported statute that can unite many environmental organizations for common action. Donald Barry of the World Wildlife Fund states, "If there's one event that causes the diverse environmental community to hyperventilate in unison, it is an assault on the Endangered Species Act" (Barry, 1991).

The Omnibus Reclamation Act of 1992 suggests change in the political climate in favor of wildlife. This Act requires that irrigation water allocations in the Central Valley Project of California be adjusted to protect wildlife. The Act directs the Interior Department to increase the amount of water flowing into the Sacramento River by 800,000 acre-feet annually, for the sake of a salmon fishery (which would not have existed except for the water projects). Water is also to be allocated to resting and breeding areas for migrating ducks and geese. Most of California's agricultural interests were strongly opposed to the bill because it tightens the availability of water to agriculture. In the past, opposition by farmers has been sufficient to forestall such restrictions, so it is noteworthy that such legislation did pass Congress by wide margins in 1992.

Consumer and Worker Safety

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) was enacted in 1947 to assure farmers that pesticides would be effective as advertised. The focus of FIFRA shifted in the early 1970s to protect humans and wildlife against health risks from pesticides. Two key tools are EPA's registration of pesticides, and worker safety rules.

EPA initiated its Rebuttable Presumption Against Registration (RPAR) process under FIFRA in 1975, to withdraw toxic pesticides from the market. From the beginning, the regulatory process was plagued by the volume of pesticide formulations on the market — some 35,000 according to the National Research Council, although only a few hundred active ingredients are involved. The process is costly for both the government and manufacturers who must supply much toxicological and other safety and environmental data.

In the 1988 reauthorization of FIFRA, Congress mandated EPA to re-register all pesticides against the current and more stringent standards. EPA was given a tight deadline for doing so, and was authorized to impose registration fees to finance extra personnel needed to accomplish re-registration in the allotted time. The results have been dramatic. Companies dropped many registrations (a registration covers use of a chemical on a specific crop) rather than pay the registration fees. Gianessi and Puffer (1992, p. 58) state: "During the past four years, more pesticide registrations have been voluntarily dropped by manufacturers than have been cancelled by EPA in its entire history."

A current concern is the consequences for "minor use" pesticides that have specific applications for smaller markets, such as certain fruits and vegetables. Total expenditures on pesticides in minor use markets are substantial, an estimated $660 million annually. But unlike chemicals used on major field crops, fruit and vegetable usage is spread over several thousand individual pesticide registrations covering several hundred different crops. As a result, revenues are measured in thousands, not millions of dollars. It is often not worthwhile for manufacturers to undergo expenses of registration (the costs of carrying out a battery of toxicological tests, tests on residues and environmental fate, plus registration fees) for the sake of access to such small markets. Unfortunately, some relatively benign chemicals used in integrated pest management (IPM) programs have been dropped for this reason. Gianessi et al. (1992) cite a walnut IPM program in California that no longer exists because the manufacturer stopped selling the insecticide phosalone due to cost of reregistration.

FIFRA also addresses worker safety. The people most heavily exposed to pesticides — thousands of times more exposed than consumers — are farmers and those workers who manufacture, distribute, and apply pesticides. Applicators are particularly exposed. EPA worker protection standards, promulgated under FIFRA in 1974, have been revised. They focus on mandatory training of workers, notification, safety equipment, and provision of protective clothing and equipment (respiratory and eye protection). In addition, there are restricted entry intervals, which leave time for toxic substances to degrade before workers can go back into treated fields.

EPA decisions on pesticide registration also turn on worker safety. Cropper et al. (1992), attempting to explain why EPA banned some pesticides and not others, found that exposure of workers to potential cancer-causing substances was a key factor. In comparison, consumer exposure to pesticide residues on foods was a negligible issue.

There is considerable controversy over the risks of worker exposure to pesticides. EPA's regulatory impact analysis cites up to 300,000 cases of farm workers poisoned by pesticides each year. Yet there is little actual data on this subject, the most carefully monitored being hundreds of cases of pesticide poisoning in California. Even minor errors in extrapolation can make a big difference in scaling up estimates in these circumstances.[7]

FIFRA is up for Congressional reauthorization in 1993/94. Reregistration, especially of minor use chemicals, and worker protection are sure to be at the forefront of the legislative debate.

Food Safety and the "Delaney Clause"

The "Delaney Clause" of the Food, Drug and Cosmetics Act forbids the use of any substance in processed food that has been found to cause cancer in laboratory animals. The Delaney Clause has become increasingly controversial with scientists' increasing abilities to detect miniscule quantities of substances that have caused cancer in laboratory animals using huge doses. Many substances occur naturally in food products, which cause no known or suspected problems when consumed in small quantities, even though they are carcinogenic to laboratory animals in large doses. The EPA, adopting a 1987 recommendation by the National

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[7]For discussion of this issue, see Wasserstrom and Wiles (1983) and Coye (1985).

Academy of Sciences, has argued against banning chemicals having negligible human health risks. However, a June, 1992 decision by the 9th Circuit Court of Appeals reaffirmed that the Delaney Clause has to be interpreted literally, meaning no detectable amounts. The Supreme Court, by refusing to hear an appeal, let this ruling stand in February, 1993, causing EPA to revoke permission for use of five pesticides used on fruits and vegetables. Thus, Congress must explicitly amend the Food, Drug, and Cosmetics Act to permit the use of a "de minimis" standard for processed foods.

EPA Administrator Carol Browner stated that EPA continues to believe that the chemicals affected by the Supreme Court's decision pose only negligible risk, and she promised that the Clinton Administration would work with Congress to develop new food safety legislation.

The 1990 Farm Act reflected concerns about pesticides and food safety through pesticide recordkeeping requirements for farmers, and through research and studies on several pesticide issues. Also, "Circle of Poison" legislation mentioned earlier almost became part of the 1990 Act. This title would have prohibited the export of pesticides not approved by EPA for use in the U.S.. Proponents of this prohibition argue that fewer products having residues of these pesticides would be imported back into the United States. Opponents argue the risks are negligible, and would not be changed by the prohibition, since manufacturing of banned pesticides would move offshore. The only sure effect then is damage to U.S. exports, and reduced employment by U.S. firms. This issue is likely to resurface in the 1993/94 FIFRA debate. Stiffening farmers' recordkeeping requirements and other regulations will likely be on the agenda.

The agenda will also include labeling requirements for all foods (except meats and food served in restaurants), as required by the Nutritional Labeling and Education Act (NLEA) of 1990. USDA has developed parallel labeling guidelines for meat products. It is likely that there will be pressures to extend the labeling approach to issues beyond nutrition. USDA is already drafting regulations for certifying "organic" foods and labeling claims that food products are pesticide or chemical free. Some businesses have labeled products to be free of genetically engineered substances, and some states and localities are moving into regulation on such matters. The policy issue is how far the federal government should go in requiring or regulating the use of such labels.

Regulation of Biotechnology

The term "biotechnology" is used to describe recombinant DNA research, and more broadly to refer to a range of modern biological research and development efforts: animal growth hormones replicated in fermentation, notably bovine somatotropin (BST) and porcine somatotropin (PST); transgenic pest-resistant plants, such as cotton that produces the bacteria *Bacillus thuringiensis* (Bt) to kill insects; the development of herbicide-tolerant crops such as glyphosate-tolerant soybeans, so that weeds can be eradicated more effectively; and products that are synthetic but biochemically the same as plant or animal products, such as cell-cultured vanilla. These are instances where particularly impressive progress has occurred, but the general point is that a range of productivity and quality enhancing technologies that could affect many food and fiber commodities is now within reach.

No single law regulates biotechnology. The National Institutes of Health and the Animal and Plant Health and Inspection Service (APHIS) of USDA regulate the narrowly defined area of field testing of genetically engineered organisms. The Plant Pest Act gives APHIS oversight of the field testing of transgenic plants. More broadly, products of biotechnology are regulated under FIFRA and the Federal Food, Drug and Cosmetics Act. Currently, plants, even transgenic plants, are excluded from FIFRA oversight and registration requirements, but this situation is likely to change through legislation or regulation.[8]

The Food Security Act of 1985 authorized USDA to establish controls over the development and use of biotechnology in agriculture. USDA's Office of Agricultural Biotechnology has published guidelines for field testing of genetically altered organisms for institutions receiving USDA support, but these recommendations are not legally binding (see Larsen and

[8]For example, amending 40 CFR part 152.20 to exclude transgenic plants from the FIFRA exemption.

Knudson, 1991). USDA has not yet exercised its authority to assume broader regulatory control over developments in agricultural biotechnology, but the Clinton Administration has recently tightened the detailed regulations for field testing of genetically altered crops.

While the biotechnology policy agenda for 1993 and beyond is not well defined, biotechnology regulation may be one of our most important issues in terms of economic consequences. USDA, EPA, FDA, and other agencies will be seriously considering new and more comprehensive regulatory steps. In Congress, legislation has already been proposed and more will follow. USDA research support for the development of herbicide-resistant crops is under legislative attack by people who argue that such crops encourage the heavier use of herbicides, which would have adverse environmental consequences. The counter argument is that herbicide-resistant plants lead to a substitution of herbicides that are used at lower rates per acre for older, high rate materials. Most of the newer herbicides and insecticides registered are used at much lower rates, and are environmentally safer.

Probably the best-known debate is over the use of BST. Wisconsin's legislature has rejected a number of bills to restrict or ban BST, but has delayed its commercial use. Representatives of Wisconsin have introduced several different types of bills in both the U.S. House and Senate to restrict BST use. Analogous anti-biotechnology efforts can be expected as other biotech products and production methods approach commercialization. The combination of farmers' worries about surplus production, and consumers' fears of chemicals or "foreign" substances in foods, is a potent combination. The concerns on the consumer side appear sufficiently strong, if unpredictable, that regulation building consumers' confidence may be necessary for biotechnical innovations to succeed commercially. Even though FDA found no reason to question the human consumption of milk from cows treated with BST, and milk from BST trials is widely marketed in the U.S., some dairies have thought it prudent to publicly announce they would sell no milk from BST trials or use no milk from cows treated with supplemental BST if it is approved.[9] And just recently, a 90-day moratorium on its sale (following FDA approval) was signed into law.

Another example, not an innovation in biotechnology but raising similar fears, is the reaction of some consumers against food irradiation as it becomes commercialized in Florida. Irradiation kills bacteria, including salmonella, which cause an estimated 9,000 deaths per year in the U.S. and many thousands more illnesses. These bacteria are the greatest current food safety risk, as shown by recent deaths and illnesses due to bacteria in improperly cooked fast-food hamburger. In addition, the shelf life of irradiated products is extended, and packaging needs are reduced. Moreover, irradiation has long been used without incident in many consumer applications, and has been approved by the major international food and health organizations. Yet, no one seems able to quiet consumers' fears. Only widespread consumer education and experience with the actual product can overcome consumers' concerns.

This situation creates some of the more difficult legislative minefields, where government doing nothing at all can be as commercially disastrous as overregulation.

Summary

The regulatory agenda has no one unifying theme except environmental and health concerns. The implications of the various policies for agriculture vary, and often the same legislated goal has very different economic effects, depending on how the goal is pursued through legislation and implementing regulation. What is worrisome to the agricultural community, and for the economic health of the nation, is that fears will overwhelm rational public choice and lead to harmful regulation that generates little environmental or food safety gain. To make rational regulatory decisions, it is crucial to know the economic risks. This is the subject of the following section.

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[9]Hoban (1992) found 66 percent of his respondents agreeing that "Biotechnology will personally benefit people like me in the next five years", but many also expressed high perceived risks. Only 20 percent found tomatoes made better tasting by "genes added from a virus" acceptable. Campbell Soup recently delayed marketing products using a flavor-enhanced tomato developed by Calgene, and indicated they would only market bioengineered products with complete government approval and in response to consumer demand.

IV. Economic Assessment of Regulatory Policies

The size and scope of the regulatory agenda understandably concerns farmers and others in the agricultural sector in regard to economic consequences. The agenda is also daunting from the analytical viewpoint. A number of economists have analyzed the consequences of environmental regulation of agriculture. Some have provided quantitative estimates of regulatory actions that shed light on the current regulatory agenda. But their analytical information is incomplete, and cannot provide a full assessment of the regulatory agenda's costs, because of unknowns about the form new laws will take. Moreover, we don't know what specific regulations would be promulgated to implement new laws. And even if we knew the laws and regulations precisely, reactions of farmers, agribusiness, and consumers to the changes are uncertain.

This discussion of the evidence proceeds in three steps: First, a qualitative outline of prospective actions and consequences is presented for each major agenda item. Second, analytical work by economists and supporting scientists is reviewed as it bears on the prospective regulations. Third, a synthesis of these estimates is presented.

Prospective Actions and Consequences

Table 5 presents an outline of qualitative effects. The areas of legislation and regulatory action are listed in the first column. Each of the other columns represents an economic variable that may be affected by the regulation. In this table a minus ("-") indicates that the variable decreases as a result of the regulatory intervention, while a plus ("+") indicates the variable increases. A zero indicates little or no change. A +/- indicates some farms, regions, or businesses will experience an effect in one direction, and some in another, with the overall effect being uncertain.

The most predictable feature of the regulations is that they raise farmers' and consumers' food costs, while reducing the nation's GDP. Further economic consequences vary. The most important consideration is whether the regulation affects all producers of a commodity, or only a small subgroup. If all or most producers are affected, then aggregate farm output

New Regulations	Consequences									
	Crop Acreage	Farm Output	Production Costs	Farm Income[2]		Farm Asset Values	Consumer Food Costs	Agribusiness and Rural Community Activity	Exports	GDP
Clean Water Act				short run	long run					
— Restrictions on conversion of wetland acreage to other uses	-	-	0	-	-	-	+	-	-	-
— Restrictions on fertilizer and pesticide use to curb "nonpoint" water pollution	+	-	+	+/-	-	-	+	+/-	-	-
— Possible taxes or fees on agricultural chemicals	+	-	+	+/-	-	-	+	+/-	-	-
— Restrictions on waste disposal from livestock enterprises	0	-	+	-	-	-	+	0	0	-
Endangered Species Act										
— New recovery plans, which include cropping restrictions, water use restrictions, and pesticide restrictions	-	-	+	-	-	-	+	-	-	-
— Reauthorization with more drastic steps for preserving endangered species	-	-	+	-	-	-	+	-	-	-

- indicates a decline
+ indicates an increase
0 indicates little change
+/- indicates the effects will be + for some farms or businesses and - for others, with the preponderance of effect uncertain
? indicates effects will depend on details of regulations not known at present

[1]In addition to national effects, some regulations have regional effects which can complicate the picture. For example, restrictions on a pesticide can increase farm income in regions that do not use that pesticide, because output in competing regions that use the pesticide is reduced.

[2]Short run and long run effects are separated because demand may be sufficiently inelastic in the short run that land use and other input restrictions could possibly drive up commodity prices enough to cause net farm income increase. Hence the ? for many policies. But in the long run, shrinking markets, especially export markets, are likely to prevent high prices from being maintained.

Table 5. Prospective New Laws and Regulations' National Economic Consequences (cont'd)

New Regulations	Consequences									
	Crop Acreage	Farm Output	Production Costs	Farm Income[2]		Farm Asset Values	Consumer Food Costs	Agribusiness and Rural Community Activity	Exports	GDP
FIFRA, and Related Provisions in the 1990 Farm Act				short run	long run					
— Continuing reregistration of pesticide formulations under new provisions by which manufacturer bear registration costs	0	-	+	+/-	-	+/-	+	+/-	-	-
— Pesticide recordkeeping for farmers	0	0	0	0	0	0	0	0	0	0
— Restrictions on pesticide applications and applicators	0	-	+	+/-	+/-	+/-	+	+/-	-	-
— Revised regulations for farm worker protection	0	0	+	-	-	+/-	+	+/-	-	-
— Possible restrictions on pesticide exports	0	0	0	0	0	0	+	0	-	-
— Regulation of pesticide residues on food crops	0	0	+	-	-	-	+	+/-	-	-
Biotechnology Regulation										
— Transgenic plants brought under FIFRA — Restrictions on research and testing of genetically altered materials — Restrictions on food use of livestock products using bioengineered hormones, vaccines, or other medicines — Restrictions on commercial use of transgenic plants	+/-	-[a]	+	+/-	-	-	+	+/-	-	-

[a]Effects of biotechnology regulation are relative to future events if biotechnology were less regulated, not relative to the current situation

Table 5. Prospective New Laws and Regulations' National Economic Consequences (cont'd)

New Regulations	Consequences									
	Crop Acreage	Farm Output	Production Costs	Farm Income[2]		Farm Asset Values	Consumer Food Costs	Agribusiness and Rural Community Activity	Exports	GDP
Promotion of "Sustainable" Agriculture				short run	long run					
— Targeted federally funded research	+	+	-	+/-	+	+	-	+/-	+	-
— Possible standards for organic products, enforcement financed by user fees	?	?	?	+/-	+/-	+/-	?	+/-	?	?
Soil Conservation										
— Implementation of conservation compliance plans	-	-	+	-	-	-	+	+/-	-	
— Further tightening of "sodbuster" and "swampbuster" provisions	-	-	+	-	-	-	+	-	-	-

will be reduced, and commodity prices will increase. The price rise may be sufficient to offset the regulatory cost increase, in which case, agribusiness buyers and food consumers bear the burden of the regulation. It is possible for a regulation which reduces output to increase farm income, if demand is unresponsive to price.

If a regulation affects only a relatively small fraction of a commodity, such as the reduction of irrigation water to preserve an endangered fish in a small rice-growing area, then commodity prices will not rise appreciably. In such cases, directly affected farmers will absorb the income loss, and will suffer a possibly crippling loss in their land values.

Even when commodity prices rise, the farm income effect will often be negative if demand is responsive to price. The situation is analogous to annual acreage reductions in commodity price support programs. Even if acreage idling provides a short-term income boost to farmers, the longer-term consequences are typically negative, both for farmers and for the whole economy. A similar situation exists for acreage idling in pursuit of environmental goals, and for restrictions on the use of chemical inputs.[10] In general, the responsiveness of demand — particularly of export demand — increases with the time allowed for economic adjustments. This is why effects of farm income and asset values are divided into "short-run" and "long-run" columns.

Effects on agribusiness and rural communities, apart from farmers themselves, are even more conjectural. Regulations restricting some activities are sure to stimulate other activities, and some businesses and communities will gain. Enterprises providing substitutes for restricted inputs will do well, and areas not subject to a pest, whose pesticides are restricted, will gain when the infected areas lose. Nonetheless, because of the tendency for farm costs to increase, the tendency of regulation is to reduce output, employment, and income in agribusiness and rural areas.

Even when the qualitative effects are clear — as in the case of consumers' food costs —

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[10]See Hertel (1990) for a detailed economic assessment of output reducing policies.

it is difficult to obtain reliable quantitative estimates of prospective regulations. Nonetheless, economists have devoted a good deal of analysis on the agricultural economy to provide helpful information on likely consequences of regulation. This is particularly true of regulations that restrict chemical and land use.

Restrictions on Chemical Use

Econometric work has been carried out to provide estimates of results that can be expected from wide-ranging restrictions on fertilizer and pesticides. One approach is to look at the production effects of these chemicals.

When agricultural economists began detailed statistical studies of productivity growth in U.S. agriculture in the 1950s, one of the most striking results was the large contribution of fertilizers and pesticides. It was estimated in the 1960s that an additional dollar spent on fertilizer or pesticides increased the value of output by $3 to $5 (Griliches, 1964; Headley, 1968). These estimates of remarkable productivity gains from chemicals imply that a forced reduction in the use of chemicals would have serious consequences for farm productivity and production costs. Such estimates also imply that profit-seeking farmers should have dramatically increased their use of fertilizers and pesticides in the 1960s. Indeed they did: according to USDA, chemical input use increased sixfold between 1950 and 1980, a growth rate of 6 percent annually.

Headley used his results to estimate that controlling insect, weed and fungal populations with pesticides generated benefits of $1.8 billion annually.[11] Since this benefit resulted from pesticides that cost about $400 million, there would be a large net loss from the absence of these chemicals — amounting to about a 10 percent increase in the cost of U.S. crop production. A similar result for fertilizer would imply a cost increase of about one-third if all chemicals were withdrawn (more than doubling the pesticide loss because fertilizers are a more

[11]This estimate takes the marginal effect of the last dollar spent on pesticides as equal to the average effect of all pesticides used. Since the most valuable uses are presumably done first, the marginal effect should be lower than the average effect, and Headley's estimate should underestimate the total benefits of pesticides.

important input quantitatively).

More recent studies indicate that the productivity of pesticides remains high. Pimentel and Pimentel (1983) state that "at present rates of use, $1 invested in pesticide control returns about $4 in increased crop yields" (p. 13), based on a total of $2.2 billion spent on controlling pests saving about $9 billion worth of crops. Another recent estimate is that pesticides generate about $6 in additional output per dollar spent (Carrusco-Tauber and Moffitt, 1992). Moreover, there is evidence that pesticide productivity is even higher when effects on the quality of output (in their case, reducing insect damage to apples) is taken into account (Babcock, Lichtenberg, and Zilberman, 1992).

While estimates of chemical productivity vary substantially, they are uniformly high. This suggests that even a small reduction in chemical use would cause a significant increase in farmers' net production costs if no substitute chemicals were available. Yet, while EPA banned 9 chemicals and placed some restrictions on 26 others in the early 1970s, there do not seem to have been measurable aggregate effects. This is because the restrictions did not cover all pesticide uses, some of the restricted ones were losing their effectiveness anyway, and substitute chemicals were available.[12] A large decrease in chemical use, say 20 percent or more, would be expected to be a quite serious matter. Unfortunately, econometric work using actual data are not very helpful in providing quantitative estimates for large changes, because there is no way of judging whether the relationships are still applicable in hypothetical situations that may utilize input mixes far from current observations.

Another means of assessing effects of sweeping chemical reductions is through simulation models of commodity markets. In 1990, GRC Economics analyzed the absence of pesticides and inorganic fertilizers in the production of corn, soybeans, wheat, rice, cotton, and (aggregated) fruits and vegetables. A sample of the estimated effects, taking into account farmers' economic adjustments to the absence of these inputs, is shown in Table 6 for the

[12] See Carlson, 1977; Reichelderfer, 1990.

Table 6. Estimated Effects of Absence of Pesticides and Fertilizers in 1995/96

	Baseline	No Chemicals	% Change*
corn yield (bu./acre)	131.6	61.4	-53
corn acreage (mil. acres)	68.5	68.4	-0
corn exports (mil. bu.)	2703	475	-82
corn price ($/bu.)	$2.31	$3.80	65
soybean yield	35.4	19.9	-44
soybean acreage (mil. acres)	58.1	59.6	3
soybean exports (mil. bu.)	675	290	-57
soybean price ($/bu.)	$5.87	$8.62	47
wheat yield (bu./acre)	41.0	19.8	-52
wheat acreage (mil. acres)	67.5	71.1	5
wheat exports (mil. bu.)	1574	634	-60
wheat price ($/bu.)	$2.88	$4.41	53
cotton yield (lbs./acre)	692	153	-78
cotton acreage (mil. acres)	11.37	12.96	14
cotton exports (mil. bales)	6.85	-2.0**	undefined
cotton price ($/lb.)	57¢	73.5¢	29
fruit output			-32
vegetable output			-21
peanut output			-68

* Using the baseline value as the denominator
** The minus sign indicates net imports

Source: GRC Economics, 1990, p. 42 and Appendices A and B

1995/96 crop year. The key assumptions are yield effects taken mainly from USDA estimates published by the Economic Research Service.[13] USDA's estimates typically do not involve simultaneous loss of all pesticides and fertilizers, so the aggregation must be done in ad hoc fashion.

The no-chemical yields look low, but are consistent with the high productivity of pesticides and chemicals in the econometric work cited earlier. The no-chemical yields are at U.S. average levels of the 1950s before chemical use was widespread (except the simulated no-chemical yields are lower than actual 1950s yields for cotton). Reduced output raises farm prices, and the higher prices encourage additional crop acreage. In this sense, chemicals and land are substitutes. The biggest quantitative effect of a lack of chemicals is in agricultural exports, where losing the competitive edge causes drastic losses of markets.

GRC estimates the consumer price index for food rises by 45 percent, but does not explain this result. Since farm commodities account for only about 30% of the retail value of food, the average price received by farmers would have to rise by roughly 150 percent. The commodity price rises of Table 6 are not this large. Undoubtedly GRC is assuming increases in marketing margins, but the basis for this is not stated.

The GRC study made no estimate of the effects on farm income.

A second study of the nationwide effects of restrictions on chemical use was carried out by Knutson and Associates (1990a). They investigate the consequences of a complete ban of pesticides and inorganic nitrogen fertilizers on 8 major field crops (corn, wheat, grain sorghum, barley, rice, cotton, soybeans, and peanuts). The agricultural science component of this study is a detailed, U.S.-wide effort to mobilize the knowledge of agronomists, entomologists, plant pathologists, and economists. About 140 scientists provided their estimates of the effects on crop yields and cost of production for six reduced-chemical scenarios. The most drastic of

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[13]These estimates are arrived at through surveys of agricultural scientists as part of the National Agricultural Pesticide Impact Assessment Program which USDA uses to advise EPA in the pesticide reregistration process.

Table 7. Estimated Yield and Costs of Eliminating Pesticides and Inorganic Nitrogen

Commodity	Percent Change in Yield	Comparable Estimate from GRC study[a]	Change in Costs ($ billion)
Corn	-53	-53	9.4
Wheat	-38	-52	3.6
Soybeans	-37	-44	4.3
Sorghum	-37	--	0.8
Barley	-43	--	0.8
Cotton	-62	-78	6.4
Rice	-63	--	1.6
Peanuts	-78	--	2.1
TOTAL			$28.6[a]

[a]These costs are calculated using 1991 quantities, while the Knutson study uses primarily 1995-98 simulations fo their comparisons. The $28.6 billion here is thus not exactly comparable to their results.

these eliminates all pesticides and inorganic nitrogen.[14]

The main findings are shown in Table 7, with an indication of their monetary significance. Note that the yield effects are quite similar to those of the GRC study.

The no-chemical scenario generated the following estimated net changes:

gross receipts (8 crops):	+ $20 billion		
overall net farm income	+ $3.6 billion	of which:	
		crops	+16.1 billio
		livestock	-12.5 billio
consumer food costs	+ 43 billion		

Net crop income rises because higher commodity prices more than offset lower output and higher crop production costs. With about $400 billion in consumer expenditures on food, fo

[14]For details, see Smith et al., 1990.

prices would rise a little over 10 percent.

The study does not provide a quantitative estimate of the effect on government outlays, but argues that decreased commodity program costs would be more than offset by higher food program costs triggered by food price increases. Adding up the economic effects, producers, consumers, and taxpayers would be worse off by more than $40 billion annually.

A number of criticisms have been made of these studies. On one hand, large-scale simulations overstate the economic effects of chemical restrictions in two ways: 1) by not considering no-chemical alternative production methods that could substitute for chemical-intensive ones, and 2) by not considering technical change, such as new pest-resistant crop varieties that would mitigate the effects over the longer term (Ayer and Conklin 1990; Knutson et al. 1990b). These objections are relevant when considering a long period of adjustment, such as 8 to 10 years. On the other hand, the Knutson study understates the possible effects of chemical reduction in two respects: 1) it excludes all fruits and vegetables, which could be hit hardest by regulatory restrictions, and 2) its "no chemicals" scenario still uses phosphate fertilizers, which are susceptible to regulation as a contributor to water quality problems.

Since no legislator or environmental group has proposed the complete elimination of chemicals, what is the point of analyzing their elimination? The Knutson study provides partial elimination scenarios, but these involve the complete elimination of large subsets of chemicals, e.g., all herbicides. What if only selected pesticides were eliminated, and use of inorganic fertilizers was reduced by only one-third? This might reduce aggregate chemical use by an initial 40 percent, but would cause economic damages of less than 40 percent of the GRC or Knutson estimates, because remaining pesticides would substitute for the ones eliminated to some extent, and fertilizer uses given up would tend to be the least productive ones. Nonetheless, no-chemicals scenarios provide a useful outer bound.

Subsequent publications Taylor et al. (1991) and Taylor and Penson (1991) provide more relevant estimates by considering regulations targeted more precisely to environmental problems. These use regulatory scenarios provided by EPA analysts which restrict chemical use only in areas of high potential groundwater pollution. Because of limited chemical and regional coverage, the effects on commodity prices and output are much less severe than shown in tables 6 and 7. For example, banning aldicarb, triazines, and acetanilides (heavily used on corn) in high pollution areas is estimated to increase consumer food costs $1.2 billion and decrease farm income $2.4 billion annually. The estimated net social costs including federal budget changes and foreign market effects, is a net economic loss of $4.2 billion annually (Taylor and Penson, Table 1). This does not include restrictions on chemicals to protect endangered species or to address other environmental problems.

More specialized studies provide further understanding of substituting non-chemical for chemical inputs, and the role of export and domestic demand and supply conditions in determining economic consequences of partial restrictions on chemical use. Azzam, Helmers, and Spilker (1990) developed a model in which three commodities (feed grains, wheat, and soybeans) are produced using land, labor, machinery, fertilizer and chemicals, and other inputs. Assumed substitution possibilities among the inputs are then used to simulate the effects of reductions in fertilizer and chemicals used. The findings are that a 10 percent reduction in fertilizer and chemical inputs increases crop prices about 2 percent on average, and that land returns decline while labor returns rise. For a 25 percent restriction, the authors conclude that "there is little justification for concern that fertilizer and chemical reductions in agriculture would cause major problems with food price increases in the long run" (p. 11).

Where the large-scale studies made many detailed, technical assumptions about yield and cost effects of chemical unavailability, the smaller-scale studies concentrate on a few big assumptions. A major problem is that several key assumptions are based on information from the 1960s and 1970s, and the approach to measuring pesticide productivity makes assumptions that have recently been questioned (see Lichtenberg and Zilberman, 1986).

However, the estimated price effects are not that far from the large-scale simulation models. It is reasonable to expect that if a 10 percent chemical restriction causes a 2 percent commodity price rise, complete elimination would cause a more than 20 percent price rise.

Taking account of all crops, a 20 percent price rise would increase consumer costs at least $16 billion, so the Azzam, Helmers, and Spilker estimate is in the same ball park as the Knutson et al. estimate.

Chambers and Lichtenberg (1992), estimating pesticide productivity from actual U.S. output data, imply that eliminating pesticides would reduce U.S. agricultural output by 7 percent, as of 1989, for a loss of about $12 billion annually. Adding inorganic fertilizer would give an effect less than Knutson, et al., but still substantial.

Rendleman (1991) constructed a 10-sector general equilibrium model that explicitly brings in manufacturing, food processing, agricultural services, and chemical production industries. Agriculture is aggregated into three large subsectors: — feed grains and oilseeds, livestock, and all other agriculture — with no commodity detail within these subsectors. Rendleman simulates reductions in all chemical (pesticide and fertilizer) use in agriculture over a range of 5 to 85 percent. He finds that reductions up to 25 percent have very small effects, but more severe restrictions increase social costs at an increasing rate. An 85 percent reduction causes a net loss of $25 billion annually.

Rendleman also looks at returns to farmers' labor, land, and capital and finds their returns declining under chemical restrictions. He estimates that a 75 percent reduction in chemicals causes the rental value of grain-producing land to decline by 21 percent and the rental value of other agricultural land to decline by 34 percent.

Dinan, Simons, and Lloyd (1988) examine the set of EPA actions completed or considered as of 1988.[15] They find that farm cost increases generally exceed commodity price increases, so farm income falls about $0.2 billion (but with a great range of uncertainty). Consumers lose about $1.5 to $2 billion annually in the 1990s, but with a range from $0.1 billion to $4 billion across scenarios, depending on the intensity of regulation.

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[15]These include: EDB—cancellation; Toxaphene—cancellation; Dinoseb—cancellation; Chlordimeform—cancellation; Alachlor—cancellation; Fungicides: EDBCs, chlorothalonil, and captan—range of options; Corn rootworm insecticides—cancellation of most; Organophosphates—range of options; Grain fumigants—cancellation or restricted use; Aldicarb, Alachlor, Triazines—restrictions in groundwater problem areas.

The results of 16 recent studies estimating the productivity of pesticide inputs in cotton, corn, soybeans, and fruit are reviewed in Carrusco-Tauber (1990). The findings vary enough to raise questions about the precision of any one of them, but the studies provide a clear indication that pesticides make a significant difference in U.S. farm productivity, and could not be removed without substantial output loss.

Almost all the studies mentioned focus on the major crops: corn, soybeans, and cotton. This is true even of the large-scale simulations. This focus is reasonable because the growing and dominant market for pesticides is for these commodities. In 1990, of the total of $4.5 billion in pesticides shipped for domestic use, corn and soybean uses accounted for $2.3 billion compared to $660 million for fruits and vegetables.

Nonetheless, some of the most important economic effects of pesticide regulation are likely to occur in fruits and vegetables, regionally concentrated in California and Florida. The global food and U.S. export issues are less important for fruits and vegetables, but the consumer cost (and quality) issues are larger, especially because a higher percentage of fruits and vegetables are consumed in fresh form. Also, consequences for fruits and vegetables are more immediately relevant because current regulations are causing the loss of many of these pesticides.

The papers collected in Zilberman and Siebert (1990) examine the main issues in pesticide economics with special reference to California's "Big Green" initiative. These studies show how much the situation varies for different commodities, different pesticides, and different regions.[16] The complexities are such that Zilberman and Siebert do not attempt to make an overall quantitative assessment of potential effects of severely restricting pesticide use. But they do conclude that restrictions on pesticide use will increase food prices, and that pesticides are not currently over-used by growers from the viewpoint of efficiency or agricultural productivity. Zilberman et al. (1991) provide quantitative estimates of the costs of (a) total elimination and (b) "Big Green" regulations on pesticides used on five major crops (almonds,

[16]In particular, see Carlson (1990) and Parker, Zilberman, and Lichtenberg (1990).

grapes, lettuce, oranges, and strawberries) in California. They estimate a loss to both producers and consumers of $1.8 billion for the ban, and $900 million for the partial regulation. These losses amount to 50 and 25 percent, respectively, of the market value of the crops.

Assessments of "Sustainable" or "Alternative" Agriculture

Rather than estimate yield effects of chemical restrictions using experts' judgments, another approach is to start from farm-level experiments using crops grown with alternative (low-input) methods. Economic literature on this topic contains a few serious efforts to assess what farmers could do with reduced or no chemical pesticides or fertilizers.

Hansen et al. (1990) compared standardized budgets for conventional farming in the Mid-Atlantic region to low-input rotations used at the Rodale Research Center. They found that the low-input approach generated profit only about 10 percent lower than conventional farming. Ikerd, Monson, and Van Dyne (1992) are even more optimistic. They simulated farm level costs for reduced-erosion and reduced chemical production for several types of farms, with essentially no cost increase. The main difference from other studies seems to be that they assume no yield penalty from using less pesticides (mainly herbicides).

Data from actual farms is less encouraging. Batte (1992) investigated costs of farming with increased organic fertilization through rotations, using more labor-intensive pest control practices on Ohio farms state certified as producers of "organic" products. These producers used less than 10 percent of the pesticides, and about one-third the fertilizers of the average Ohio farm. Comparing costs of production on the organic farms to the average Ohio farm, Batte found a reduced cost of chemicals of $13,025 for the organic farm, but a loss of yield worth $29,189. The organic farmers also lost economies of size, but gained from a more remunerative crop mix. The net effect was an extra cost of about $30,000, or $165 per acre, for the organic farms.[17] Since Ohio averaged about $185/acre in production expenses in 1990, the

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[17]The organic farms are able to stay in business because they can sell their products in the organic specialty markets for higher revenues. But this would not be possible if all farms produced by organic methods. The crops analyzed are not fruits and vegetables so the producers cannot count on obvious quality differences to create a market.

organic methods appear to nearly double costs.

The most intensive debate on costs of nonconventional farming was triggered by publication of the National Research Council's Alternative Agriculture (1989). This book reviewed case studies of 14 farms which used reduced levels of chemical inputs, without apparent economic sacrifice. This publication gave a substantial public boost to the idea of chemical regulation. As the Newark *Star-Ledger* put it: "This is the most devastating finding yet in the long debate over pesticides. ... If there are no benefits to American agriculture in pesticides, then there is no reason for their presence" (quoted by John Marten in CAST, 1990, p. 112).

The Council for Agricultural Science and Technology (CAST) published a collection of 41 reviews of Alternative Agriculture (CAST, 1990). The general thrust of the reviews is that the National Research Council case studies give far too rosy a view of reduced-input production as an economically viable means to restructure U.S. agriculture.

Conclusions on Chemical Restrictions

One has to be impressed with both the variability of the estimates of economic costs of chemical restrictions, and the fact that these costs are quite large under a variety of assumptions and estimating approaches.

The economic studies agree on one aspect of the incidence of these cost increases: U.S. consumers would pay a large portion of the costs in the form of higher food prices. This coul be viewed as a reasonable way to pay for environmental improvements; but the case of food i special because low-income people spend a higher portion of their incomes on food than high income people. USDA estimates that the share of income spent on food is 42 percent in the 2(percent of households with annual the lowest incomes, and 9 percent in 20 percent of households with the highest incomes. So restrictions that raised the food CPI 10 percent would be a 4.2 percent tax on the low-income households and a 0.9 percent tax on high-income households. Food stamps would cushion the very lowest income group, but the lowest 20 percent includes about 50 million people, about half of whom get no food stamps. (And to the extent that food cost rises are covered by increased food stamp allowances, taxpayer costs rise.)

There is less agreement on other distributional consequences. Some studies find that returns to farmers' labor and land would decline (e.g. Rendleman). Others estimate that farm income would increase (Knutson et al., and probably GRC Economics, although the latter do not provide an explicit estimate). Nonetheless, there are good reasons to expect the long-term farm income consequences to be negative, because long-term prospects for U.S. agriculture depend so heavily on competitiveness in international markets.

A farm income issue that is not addressed quantitatively in the studies, is the differential effects of chemical restrictions on large versus small farms. Large farms tend to be chemical-intensive, and alternative agriculture experiments tend to be in small-scale farming. But the small- or mid-scale farms that do use chemicals — which is the great majority of them — may be in a particularly poor position to cope with fertilizer or pesticide restrictions. Permitted practices and behavior are likely to be highly knowledge-intensive. Large farms will have the scale to justify acquiring and maintaining, or hiring, this knowledge more than small farm operators.

Perhaps more important is the differential effect by region. Many pests are regionally specific. For example, if all soybean producers would not have declining net income, (because the soybean price rise offsets the quantity loss), the quantity loss will be much greater in the South where pests are a greater problem. So Corn Belt soybean growers could actually prosper under pesticide restrictions while Southeastern and Delta producers would be devastated.

Biotechnology Regulation

Economic consequences of biotechnology policies are difficult to estimate because regulation typically does not restrict activities, but rather delays or prevents innovations that would otherwise occur. One of the most widely discussed innovations is biotechnology produced growth hormones, especially bovine somatotropin (BST), which significantly increases milk production in the latter months of cows' lactations. Although milk yield increases up to 15 percent have been reported for well managed herds, BST may only reduce costs by 2 to 4 percent after accounting for costs of hormones and extra feed (Prescott et al., 1992). Still, a net gain to the nation of about $500 million annually from this single innovation is implied, which would mostly be realized by consumers in lower dairy product prices.

Similar gains may be expected in pork production through the use of porcine somatotropin. And, eventually, beef, poultry and fish present opportunities for analogous productivity gains.

Perhaps even more important will be biotechnology innovations in plant disease resistance and pest control. Estimates from costly activities such as boll weevil eradication by traditional painstaking methods indicate rates of return of 100% on funds expended (Carlson, Sapple, and Hammig, 1989). Biotechnology offers prospects of substantially higher rates of return by eliminating pest damage in crops at lower cost and without environmental risks. An example is development of cotton containing the bacillus Bt, which can greatly reduce use of chemicals to control cotton insects. Developments in cotton are particularly important because cotton now uses about 40 percent of all U.S. insecticides.

Another notable example is the development of soybeans resistant to glyphosate. Glyphosate is a herbicide that kills both grasses and broadleaf weeds. Most herbicides have primary control of only one or the other. Glyphosate is applied on emerged weeds rather than to the soil as a preemergent herbicide. It has low toxicity and degrades relatively quickly. EPA classifies glyphosate as environmentally benign compared to other herbicides.

This example is notable because of the legislation mentioned earlier that withheld funds for research on pesticide-tolerant plants. It was argued that such innovation would increase pesticide use and environmental damage. Gianessi (1991) reviewed the evidence on both economic and environmental effects of glyphosate-tolerant soybeans. The situation is complicated because of many regionally specific differences, and the many substitute herbicides available. The findings indicate that delay or omission of glyphosate tolerant soybeans would involve net costs on <u>both</u> economic and environmental grounds.

Each year that such innovations are delayed from commercial adoption, lost productivity gains can easily be reckoned in the billions of dollars. Any precise estimate would be very conjectural, but over-regulating biotechnology carries the threat of crippling the nation's innovative approach to agricultural production and environmental improvement that has made us the world's leader for the past half century.

The consequences of restrictions on biotechnology are similar to those of chemical reduction. The main economic losses would be borne by consumers, through discontinuation of the historical trend of decreasing consumer food costs.

Moreover, biotechnology is important as a source of pesticidal controls that are relatively environmentally benign. If existing chemicals are to be even more heavily restricted, it will be especially important to encourage, not discourage biotechnical innovation. Indeed, a positive policy of fostering biotechnical innovation, perhaps with incentives for replacing chemicals that cause water quality or other environmental problems, could be a better policy alternative than regulating and taxing existing pesticides or chemical fertilizers (see Carlson, 1989). Not only is this approach more immediately cost-effective, it helps U.S. agriculture to increase its international competitiveness.

Finally, U.S. international competitiveness involves not only farming, but also farm input industries, such as agricultural chemicals. These industries appear quite mobile over the intermediate and long term. There would be substantial economic loss, and little or no environmental gain, from driving them off-shore. But this would likely be the result of excessive regulation of biotechnology development.

Impacts of Land-Use and Water Regulation

From the farmers' viewpoint, a sharp distinction exists between attaining conservation and environmental goals through programs that pay for recommended practices (Conservation Reserve Program, Agricultural Conservation Program, Water Quality Incentive Program) and programs that tax or mandate farmers' land use (Swampbuster, Section 404 of the Clean Water Act, conservation compliance). But in some important respects the two approaches are similar. Both the "carrot" and "stick" incentives cause cropland to produce less output than otherwise, raise consumer costs of food, and harm U.S. export competitiveness.

While comparison is difficult because of differing qualities of land and producer incentives, the current Conservation Reserve Program is the equivalent of about a 10 percent wheat acreage reduction program and a 5 percent corn acreage reduction. The economic effects of other programs that regulate land use have so far not been nearly as significant in terms of acreage idled. But they could become more important. The environmental program with potentially the largest significance for land use is the Endangered Species Act.

Recovery plans for endangered species involve protecting habitats which could cover large areas. Endangered and threatened species are found in every state. But the area covered, and the changes in farming practices required, are hard to predict. For example, assistance for the Delta Smelt in California may force land out of production because of insufficient irrigation water, but the acreage has not been quantified. Some land held out of production under the rice program in recent years has become infested with kangaroo rats. Because they are an endangered species, it may not be possible to return this land to production. Even when land use is not directly affected, farm costs can be increased substantially by recovery plans. Weeds, such as a species of thistle in Indiana, can be protected. Practices which promote the recovery of these weeds are likely also to promote the growth of other weeds, and thus raise costs — and result in increased use of pesticides — in neighboring areas.

Cropland in critical habitat areas is still relatively small: EPA estimated 500,000 to 600,000 acres in 1991. But with over 400 new endangered species projected to be added by 1996, the acreage affected is certain to expand dramatically. More stringent administration of the Act could remove pesticides from use in certain areas, divert water customarily used by producers of agricultural crops to wildlife uses, or regulate farming activity in endangered species habitat that might damage either the species or the habitat.

Economic effects of the recovery plans will be quite different from the effects of sweeping chemical restrictions or acreage idling programs. The latter either provide payments to farmers, as in the Conservation Reserve, or result in market-wide output reductions that increase prices and thus cushion the blow to farm income in the short run. Endangered Species

Act regulations will have more serious effects on limited areas. In parts of California where water can no longer be obtained, or in other areas where regulations cause costs to rise, the economic effects will be concentrated on the local landowners. The value of their land and associated assets will fall precipitously. Chemical restrictions are estimated to have a number of adverse economic consequences, but Endangered Species Act regulations may well be even more damaging, albeit for smaller groups of producers.

Because Endangered Species Act recovery plans are locally concentrated, they also have rural development implications. Congress recognized this hazard when it limited to 25 percent the amount of a county's cropland going into the Conservation Reserve. The Endangered Species Act contains no such limit. If a whole county is home to an endangered species, then the whole county will be included in the recovery plan. The "god squad" mentioned earlier was intended to provide an economic safety value, but the experience with the spotted owl controversy indicates that this approach is too cumbersome, expensive, and political.

Beyond the effects on farmers and others in the private sector, the Endangered Species Act is notable for high administrative costs. This comes from so much detailed preparation and development for each specific regulatory venture. The National Cattlemen's Association (1992) cites costs of $115 million just to list all species now on the candidates' list, and a $7.9 million cost per species for the development of recovery plans. Applying this figure to the 750 species currently listed indicates a $6 billion cost for development of recovery plans.

Secretary of the Interior Bruce Babbitt has indicated the Interior Department's efforts to implement multi-species habitat protection plans as a preventive measure. This could save administrative costs, but could also increase the economic problems of rural areas by covering wider areas with more comprehensive restrictions on farming and ranching.

Summary of Land-Use Issues

If we consider all land-use regulations together — commodity programs, conservation and wetland reserves, conservation compliance, and endangered species recovery plans — we do have nationally significant economic effects. The economic effects of acreage idling or supply management have been estimated in many studies, notably work carried out in preparation for the 1985 and 1990 farm bills. These studies are not reviewed in detail here, but it is noteworthy that their findings run parallel to those of the pesticide restriction studies. A requirement to idle land has many of the same market consequences as a requirement to eliminate chemicals. Output is reduced, farm input industries contract, commodity and food prices rise, exports decline, and farm income may or may not rise.

The most controversial aspect of supply management analyses has been their estimates of farm income. Some of them assumed very unresponsive farm product demand, so that a small reduction in output causes a large price rise, hence increasing farm income. However, if a supply reduction policy is maintained for 3-5 years or more, the demand for U.S. farm output is not so unresponsive to price, because international competitors will increase their output to replace our reductions.

This longer-term view won the battle of evidence in the 1980s, and most farm commodity groups and economists now do not recommend acreage reduction as a way to boost farm income. The "triple-base" program introduced in 1990 is precisely a way to achieve budgetary savings by removing land from the farm payment base <u>without</u> removing that land from production.

Removing land from production in pursuit of environmental goals will be just as harmful to farmers as restrictions on chemical use. The big difference between land and chemical regulation arises in programs such as the CRP, or the Wetlands Reserve, where farmers are paid the rental value of their land or more in compensation. But regardless of whether farmers are compensated, the commodity price, export, and consumer effects are all deleterious. And the regionally specific problems for agribusiness and rural communities can be even worse for cropland restrictions than for a pesticide restriction. If a large portion of cropland in a county is taken out of crop production, local consequences can be quite serious, as has been documented where CRP participation has been high.

V. Costs and Benefits of Environmental Policy Options

Any one of the regulatory restrictions that have been discussed would have significant economic consequences. But to view the full picture, it is necessary to consider them in aggregate. These changes almost all push the agricultural economy in the same direction—placing pressure on our cropland base, raising costs, reducing exports, and increasing food prices, while at the same time reducing asset values and draining economic activity from rural areas.

If regulation proceeds simultaneously in all areas discussed, the economic impacts are compounded. The effects of chemical restrictions can be moderated by farmers' ability to substitute land and labor for chemicals. But when the reduction of land available for crops through wildlife protection and soil conservation programs is added to restrictions on the use of chemicals, the economic effects of the whole are larger than the sum of each of the component programs.

Analysis is further complicated by federal legislation that provides overall regulatory mandates, but leaves details up to state-level authorities. For example, EPA guidance for implementing 1990 Coastal Zone Management Amendments lists areas for regulation as soil erosion, confined animal facilities, and fertilizer and pesticide applications to cropland. State regulations under this Act (covering 29 states) would compound the economic effects of national regulations in these areas. EPA's Regulatory Impact Analysis estimates the national costs of compliance at $107 to $129 million (RCG/Hagler, Bailly Inc., 1992). But this analysis assumes that a 10 percent reduction in chemical and fertilizer use will involve no net economic cost (op. cit. p. 4-2). This is unlikely even under the lowest estimates of the economic value of chemicals and fertilizers, and is especially unlikely for these regulations added to all the others discussed.

A related problem is that different regulatory activities interact in ways that interfere with environmental effectiveness. For example, in a Conservation Compliance plan, a farm might adopt no-till crop production methods which refrain from turning over the soil with a moldboard plow. But plowing kills weeds, and no-till methods typically use more herbicides. So one environmental problem is improved at the risk of making another one worse. Similarly, the loss of yield due to restricted fertilizer or pesticide use can be moderated by producing crops on more acres. But this will increase soil erosion. It is already clear that stiffened EPA registration requirements are delaying the introduction of chemicals that are environmentally preferable to ones they would replace. Moreover, restrictions on new pesticides can result in more rapid development of pest resistance to older ones; hence, raising the dosage required.

The most important threat of counterproductivity is in biotechnology, where inhibiting innovation would forestall environmental improvements. Biotechnology is the most promising approach to developing environmentally benign pesticides to replace current ones. Furthermore, biotechnology is the most promising source of productivity growth to help offset the output-reducing effects of environmental regulations. Also important is that expanded production is needed to feed a world population that grows annually by 90 million — equivalent to adding a country the size of Mexico to the world each year.

In short, it is vital that legislative and regulatory actions in the environmental area not be carried out in a piecemeal fashion, with regulations imposed in one area blind to policy developments elsewhere. It is unlikely that policymakers would enact a complete ban on chemicals, with the huge adverse economic consequences this would entail. But it is not so hard to see how regulations might be developed incrementally that would reduce fertilizer use by 20 to 30 percent, pesticides by 30 to 40 percent, and land in crops by 3 to 5 percent, while simultaneously delaying the development and commercialization of biotechnology substitutes. Such action would further impose increased costs to farmers and agribusiness through labelling requirements, licensing, worker safety, recordkeeping, residue testing, and user fees or taxes to finance environmental activities.

What would be the consequences of such a regulatory blanket thrown over U.S. agriculture? Many analytical pieces of an answer are available, especially for chemical and land use restrictions. In considering the aggregated effects, it is helpful to break the issue down in two ways: short-run versus long-run effects, and for domestically consumed commodities versus exported products.

The short-run employment impacts of regulations are neglected in most of the earlier cited studies. These studies typically consider that farmers, input suppliers, and agribusiness enterprises are able to redeploy their resources so that alternative farming practices are used, unemployed input supply facilities and workers are re-employed elsewhere, and so forth. But in the short run, the consequences for both farmers and rural economics can be more severe.[18]

With respect to employment in farming, two forces are in play: first, regulations that reduce chemical use and land use in agriculture will lower output. To produce less output, farmers need less labor, so farm employment declines. The second factor is that labor can substitute for chemicals, e.g., in pest control. The question is: which effect dominates? The only studies to explicitly address this issue find the output effect dominating even under relatively long-run substitution possibilities. So environmental regulation costs jobs, but how many and for how long is not clear.

With respect to employment in the agribusiness sector, the situation is more complex. A decline in agricultural output will cause job losses in upstream (farm supply) and downstream (farm product marketing) industries. Sporleder and Liu (1992) estimate that for every job lost in dairy, for example, 1.06 jobs are lost in upstream and downstream industries, for a total loss of 2.06 jobs.

Such estimates are misleading because they do not allow for unemployed people finding new jobs, do not allow for the substitution of labor for the regulated inputs, and do not allow for the creation of new jobs in environmental control industries (e.g., insect scouts). But

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[18]How long the "short run" persists depends on the overall health of the economy. If the economy is healthy and growing, people displaced from the farming or agrichemicals industry will be soon employed elsewhere; but in a sluggish economy, many of the people displaced by a plant closedown (due to regulation, import competition, poor management, or other factors) will be added to the ranks of the unemployed, particularly in rural areas where alternatives are fewer even in good times.

they are useful as a measure of the disruptive effect that regulation can cause in a particular region. It was mentioned earlier that if irrigation water restrictions shut down a local fruit and vegetable industry, costly dislocations in the local economy will occur. Typically, the total effect is estimated by Sporleder and Liu to be about 3 times the immediate effect on the farm sector itself. Net cost calculations in the reduced-chemical analyses do not incorporate these disruptive effects. In that respect, they underestimate the cost of regulation.

The longer-run consequences depend primarily on the size of farm production cost increases, the amount of output reduction, and the extent to which cost increases are passed on to consumers in the form of higher commodity prices. The results will be different for commodities that are domestically consumed, as compared to exported products.

The most notable category of domestically consumed commodities are fresh fruits and vegetables. They are produced predominantly in California, Florida, and Texas. In these states endangered species habitats are numerous, a disproportionate share of chemicals used is likely to be removed from the market by reregistration requirements or new regulations, producers rely heavily on irrigation water, and the industry is particularly vulnerable to biotechnology issues (as in Calgene's enhanced-flavor tomato).

Economic analysis of fruit and vegetable regulation was carried furthest in the studies of California's "Big Green" environmental initiative. The general finding is that output is reduced significantly and resulting price increases absorb most of the rise in farmers' costs. Price increases range from 10 to 40 percent for individual commodities, adding to a 20 to 30 percent increase for overall consumer expenditures, while producers' revenues fall only 0 to 10 percent. Plausible federal regulation would likely not involve pesticide restrictions as severe as the proposed "Big Green" prohibitions, but will involve restrictions for endangered species protection, regulation of fertilizer and land use for water quality purposes, and biotechnology regulation that "Big Green" did not contemplate.

With U.S. farm-level value of fruits, vegetables, and related specialty crops at $25 billion, a 20 to 30 percent price increase would add $5 to $7.5 billion annually to consumer costs.

The impact on producers would be extremely variable. Producers in critical habitat areas or where increased water costs were prohibitive would see both their incomes and their asset values drop. Business failures would be common among farms highly leveraged with debt. Yet, producers of fruits and vegetables in areas unaffected or only slightly affected by regulations would have increasing incomes due to higher fruit and vegetable prices.

The result is different for exported commodities, notably grains and oilseeds. While these commodities are consumed domestically, typically as livestock feed, the markets depend on export outlets for about half of output, except in the case of corn. It is more difficult to pass cost increases on to international buyers, because these buyers have alternative sources of supply. Just as large annual acreage idling programs and embargoes in the United States gave export markets to competing suppliers such as Argentina and Brazil in the early 1980s, so output-reducing environmental regulation would cost export markets.

Studies of chemical reductions cited earlier show market prices rising sufficiently so that crop producers maintain their net incomes in the face of cost increases. In the longer term, however, such price increases could not be maintained in competition with other producers who are not subject to similar regulations. The countries of Western Europe, which are most likely to impose environmental regulations as stringent or more stringent than ours, keep competitive only through export subsidies.

The cost increases indicated by studies of chemical restrictions reviewed earlier suggest that a 20 to 30 percent reduction in fertilizer use, and a 30 to 40 percent reduction in pesticide use, would increase the cost of producing major U.S. field crops by 10 to 20 percent, or $5 to $10 billion annually. Regulatory policies that required 3 percent of cropland, or roughly 10 million acres to be idled or used for restricted purposes, would cause a loss of about $500 million annually (based on a $50 per acre rental loss).

The livestock industry would see increased feed costs, as well as direct costs of water quality regulations for feedlots and grazing and haying limitations in ranching.

Most of the cost increases would be passed through to consumers of meats, fruits, vegetables, and cereals as output reductions caused prices to rise. In addition, regulations affecting packaging and labeling, as well as regulation of pesticides and other chemicals used in food storage and processing, could add several billion dollars annually to consumer food costs.

In sum, while precision is impossible when aggregating effects, some reasonable overall orders of magnitude are:

- consumer food cost increases of $10 to 20 billion annually, or roughly $250 for a 4-person household, the heaviest burden falling on lower income families.
- net farm income losses which can range from negligible to several billion dollars in aggregate. The problem is worsened because producers in certain areas would absorb most of the losses; so even if some farmers gain from higher prices, more would likely find themselves earning net losses.
- farm asset values would decline, especially in areas where endangered species recovery plans or pesticide restrictions hit hardest. Together with the income loss, asset value declines would force many farmers out of business.
- agribusiness enterprises would face a mixed picture, even more than farmers. The predominant effect, because U.S. farm output would fall, would be negative, even though some would see demand for their services rise. Even if regulatory cost increases could be passed on to consumers, which in large part is to be expected, the reduced volume of business in inputs and product marketing services, particularly in export marketing, would generate losses of several billion dollars annually.
- U.S. agricultural exports could be reduced by 20 to 30 percent, or about $10 billion annually. The resulting economic losses are largely accounted for in the producer and agribusiness losses already discussed. But beyond this, in a world where the U.S. government is willing to undertake costly initiatives to regain markets lost to unfair competition, any loss of export markets this large would lead to further costs to consumers or taxpayers as our government attempts to either restrict imports or

encourage exports of U.S. goods.

- rural communities, especially in environmentally sensitive areas, would be hard hit by loss of jobs in the short run, and generally by a loss of value of their tax base and general economic vitality over the long term. Although no quantification has been attempted in this study, these costs could total billions of dollars.

Environmental Benefits

If costs this large are to be justified, they require equally large benefits. Information on benefits is even more conjectural than for costs, but it is important to address the question of what would be achieved by the regulatory measures that have been discussed. The four most important sources of potential environmental benefits are: water quality improvement, reduced pesticide residues in food, less exposure of farm workers to toxic substances, and less harm to endangered species.

Water Quality

EPA has documented nitrate and pesticides in groundwater as discussed earlier. But no nationally significant health problems curable by the policies we have been discussing have been documented. Thus, it is hard to justify measures that involve significant national costs to fix this problem. However, it is important to keep monitoring the water quality situation, and to keep searching for efficient ways to maintain water quality. This effort begins with finding out how and under what circumstances farming activities, soil characteristics, weather and other sources combine to cause groundwater degradation. Archer et al. (1992) report on an EPA project to investigate this issue for atrazine. It is a complicated issue, but until we know whether standard farming practices really do cause problems — and that relatively low-cost remedies (concerning timing of fertilizer and pesticide application, or rates of application at certain specific locations near streams or wellheads) are not feasible — it is premature to undertake costly regulatory steps when potential environmental benefits are so uncertain, and the costly regulations may not be necessary at all.

Surface water quality concerns have been particularly important in streams, lakes such as the Great Lakes, and certain coastal areas like the Chesapeake Bay and San Francisco Bay. The most widespread problem has been pollution with nutrients, especially nitrate and phosphates. "Dead" water bodies such as Lake Erie are caused by overgrowth of algae, which consumes oxygen when it decays to the extent that most fish cannot survive. These nutrients may come from insufficiently treated municipal sewage or industrial sources, but agriculture has also been cited as a culprit. Runoff from inorganic fertilizer applications to crops is one alleged source, as is manure from livestock operations, particularly feedlots. Substantial environmental improvements have been achieved in surface water quality, in Lake Erie and elsewhere, through improvements in municipal and industrial water treatment. But it does not appear that regulation of agricultural use of fertilizers has played a role in these cases. The benefits of an enhanced regulatory agenda for agriculture are quite uncertain here, as well as in groundwater quality.

The best documented environmental gains in agriculture are mitigation of off-site damages from soil erosion. Ribaudo (1989) estimates the average damages from cropland runoff to be about $10 per acre annually. This estimate is extremely uncertain, but it does indicate that the Conservation Reserve Program, and potentially the conservation compliance requirements of the 1985 and 1990 Farm Acts, will have substantial benefits to compensate for their substantial costs. Even for the Conservation Reserve Program, however, it is questionable whether benefits exceed the costs (see Reichelderfer and Boggess, 1988; GAO, 1993). But on this subject there is some favorable evidence. Ervin (1991, p. 39) estimates surface water quality benefits from an optimally chosen 5 million acre expansion of the CRP at $24 to $81 per acre. The cost per acre of achieving these benefits could well be within this range. It is important to note that these potential net gains result from carefully selecting particular fields based on local conditions.

Food Safety

The scientific consensus appears to be that human health risks from pesticide residues in food are low — so low that we cannot attribute any currently observable health or safety problems to them (see Zilberman et al., 1991). Moreover, pesticide residues in foods are more likely to result from fumigants or other chemicals used in handling, storing, and processing commodities after they leave the farm than from pesticides used in farm production. Consequently, the expected health or food safety gains from banning or restricting pesticides used in farming are negligible. Conversely, the absence of these chemicals would increase food quality problems associated with insects and other pests that infest food products.

Nonetheless, as a recent National Academy of Sciences report emphasizes, there are risks from pesticide residues, even if they cannot be quantified. Consumers have real concerns about residues. These are apparent in opinion surveys, in public reaction to events such as the Alar scare of 1989, and the willingness of some consumers to pay higher prices for pesticide-free or organic food products. Horowitz (1992) found a very widespread (across age, sex, race, income, and educational attainment groups) concern about health risks from pesticides. Indeed, a majority of the sampled individuals believed it more important to restrict pesticides than auto emissions.[19] Even in the absence of further regulation, these attitudes will affect the markets for food products, particularly where biotechnology is involved.

Farm Worker Exposure

With respect to farm workers' exposure to pesticides, there is evidence of immediate illness from heavy exposure, but not of long-term harm. The extent of the problem is debatable. Lichtenberg, Spear, and Zilberman (1990) consider the benefits and costs of reentry restrictions for parathion on California apples to protect against wormy apples. They do not find a case for more stringent regulation. They also point out that reentry restrictions may induce increased use of pesticides because growers will use large amounts earlier in the season

[19]One surprising result from Horowitz's sample is that 486 of the 1049 people interviewed said that the use of pesticides increases the price of food and 187 said that pesticides reduce the price (380 did not answer or said there was little effect). Why did such a large fraction give the opposite answer to what all economic investigations find? Clearly, some economic education is in order. For a more general consumer survey indicating very mixed views about food and biotechnology, indicating substantial lack of confidence in governmental regulation as well as perceived risks in new products, see Hoban (1992).

as a preventative, rather than waiting to see if a coddling moth infestation develops near harvest.

Endangered Species Protection

A long-standing concern about pesticides is damage done to non-target animals and plants, such as birds that eat poisoned insects, or fish poisoned by pesticides carried into streams by rainfall runoff. These risks are impossible to quantify, but they play a role in EPA's pesticide registration process (see Cropper et al., 1992), and even more centrally in recovery plans under the Endangered Species Act. The larger question of the value of species is also uncertain, but the value is sure to be quite large. The more debatable issue turns on regulation at the margin — how large does a critical habitat need to be, and how large a population of each species does it make sense to achieve when each additional acre of habitat is costly?

Choice of Regulatory Mechanisms

In summary, environmental benefits can be identified that go some distance toward justifying the Conservation Reserve and conservation compliance, but the evidence for health or safety benefits from more stringent regulation of farm chemicals is weak. Assistance to endangered species is undoubtedly valuable. These and other environmental benefits constitute a clear case for changing farm practices whenever that can be done at low cost. This thought has led to a search for regulatory mechanisms that would be as least disruptive as possible.

The potentially large costs of environmental regulation of agriculture, and the uncertainty of benefits, indicate that careful attention should be paid to the regulatory mechanisms chosen. If new policies are to be introduced, we need to find the least economically disruptive means. The possibilities can only be sketched here, for four broad approaches: (1) mandated production practices, (2) taxes or fees, (3) environmental targets, and (4) market-based programs.

Mandated practices

These include bans on the use of chemicals, or requirements for certain production practices (such as conservation compliance). This approach is attractive when a particular chemical is thought to be a serious health threat, or regulators are certain what remedial practices are needed. To address the problem of bacterial contamination of food, federal, state, and local governments all require particular sanitary measures in dairies, restaurants, and meat packing plants.

The problem with many environmental regulations now being proposed, however, is that not much is known about their effectiveness. We really don't know, for example, if cutting farmers' nitrogen fertilizer use by 30 percent would have a noticeable effect on groundwater quality. And what works on one farm might be quite inappropriate or ineffective on another, due to differences in soil characteristics, rainfall patterns, or crop rotations. Generally, the mandatory practice approach assumes government officials know more about what practices are optimal than they really do. The risk is needlessly costly regulations, which fail to achieve the desired environmental goals.

Taxes and fees

If a chemical or practice has harmful side effects, why not levy a tax or fee on that chemical or practice sufficient to induce users to switch to a substitute practice or cut back the harmful activity? This leaves it to the producer to react, the idea being that the producer will find the economically optimal way to proceed.

Two problems with this approach are: first, in order to know how large a tax or fee to set, the government needs to know the harm that the practice causes. Do nitrates in fertilizers cause 5 cents in environmental damage per ton used, or is it $5.00? Second, for almost every practice or chemical, environmental damage varies a great deal from one region or farm to another; and on a given farm the damage depends not so much on how much of a chemical is used, but rather how and when it is used. A tax or fee is simply too blunt an instrument. This might lead back to mandating specific practices, but the problems with that approach have already been noted.

Environmental targets

A third alternative is to target the regulation specifically at the environmental goal. A feedlot could be held responsible for water running off the premises not exceeding a certain nitrate tolerance level. A farmer could be responsible for not having more than minimum pesticide tolerance levels in any product sold from that farm. Or, chemicals in a stream leaving a farm could be required to contain no more pollutants than when the stream entered the farm. Difficulties here are first, determining and legislating the appropriate tolerances, and second, the costs of monitoring these levels for every farm. Indeed, for cases like chemicals in groundwater, it is typically impossible to associate a particular farm's activities with a nearby town's well water. In addition, area-wide issues such as arise in endangered species protection do not lend themselves to this approach.

Market-based regulation

Ingenious suggestions have been made for harnessing market forces and institutions as a substitute for governmental regulation.[20] This approach typically involves creating private property rights in environmental amenities and damages. The longest-standing example is the legal rights people have to be free of annoyance (pollution) from their neighbors. If spraying herbicide on corn kills the neighbors' tomatoes, they can sue for damages.[21]

Existing policies in wetland regulation approximate a property-rights approach by allowing a farmer to mitigate the loss of one wetland by creating new wetlands of equivalent environmental value. "Mitigation banks" carry this idea a step further by allowing third parties to restore or create wetlands for pay in order to compensate for lost wetlands.

Creation of decentralized mechanisms for less individualized problems, notably

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[20]The ideas go back at least to Dolan (1971) and have been elaborated recently by authors such as Anderson and Leal (1991).

[21]Indeed, the opposite market failure may be more important: if one farmer fails to control a farm's weeds or insects, neighboring farms may be plagued by traveling weed seeds and insect descendants. For this, legal remedies are usually lacking. A subsidy to pesticide use might then be a suitable policy response.

nonpoint pollution and endangered species protection, requires new institutional arrangements. A proposal for the Clean Water Act, for example, is that responsibility for maintaining a city's water supply below a nitrate tolerance level be assigned to the municipality. Then the municipality could either build a treatment plant to remove excess nitrate, or contract with farmers or other nitrate emitters to take steps to reduce nitrate leaving their property. On endangered species, one approach is to provide an environmental coalition with funds and responsibility to draw up contracts with farmers or anyone else as necessary to preserve the species.

Several difficulties arise with these market-based solutions. The contracts for reduced emissions and endangered species protection would be complex and difficult to monitor. The contribution a typical farmer makes to these problems may be too small to be worth the transaction costs of setting up, monitoring, and enforcing compliance with their provisions. The funds necessary to buy farmers' and others' actions necessary to save an endangered species might be impossible to appropriate in these times of budgetary stringency. This raises questions about the implicit taxes being imposed on farmers and others if these actions are mandated by regulators. If saving an endangered species is too costly for taxpayers to afford, how can farmers and others be expected to pay the cost? With respect to lawsuits as remedies for environmental problems, one has to question whether more litigation is what we need.

Policy in some areas, notably clean water and clean air, has gone towards decentralization by setting federal standards, but requiring states to adapt them to their areas and to establish the appropriate regulatory regime. Should this approach be expanded? A recent study of potential water quality improvements in Iowa indicates how careful attention to local conditions can uncover least-cost ways of meeting environmental goals (Contant, Duffy, and Holub, 1993). However, such approaches require much larger administrative costs and efforts than broad-scope policies like fertilizer taxes. And, local establishment of environmental standards could lead to substantially increased costs of interstate commerce. In many policy areas, federal preemption of state or local authorities occurs for economic reasons.

In short, while there should be room for innovative, market-based approaches in environmental regulation, this approach is no panacea. The hard ending of this discussion of alternative regulatory mechanisms is that there exists no way of turning the sour medicine of regulation into a tasty repast for the agricultural economy. Under any method of implementation, large costs are inevitable.

The economic risks of overly rigid regulation and the uncertainty of benefits argues for consideration of information-based voluntary approaches, rather than regulatory mandates. The research, development, and delivery system for voluntary programs is largely in place in the U.S. Department of Agriculture, which has been a proponent of them (see USDA, 1991). There are better reasons for voluntary approaches to work in agriculture than in industry. The main point is that farmers themselves are the first to feel the ill effects of groundwater pollution, soil erosion, and related environmental problems that stem from farming practices.[22] Farmers are in fact changing their practices voluntarily. Low-till crop production methods have been vigorously adopted. Some midwestern states doubled their use of conservation tillage between 1991 and 1992, and conventional tillage with moldboard plow is down to 12 percent of corn and soybean acreage (USDA, 1993). Chemical use has stabilized, and the chemicals used are becoming more environmentally benign. Methods of "precision farming" — adjusting input quantities and production practices to highly localized climatic and soil conditions (e.g., changed fertilizer application rates every few square meters) — are being developed. Further efforts along these lines are a wiser course than bringing out more heavy regulatory artillery.[23]

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[22]For a fuller discussion of these incentives, see Norton, Phipps and Fletcher, 1992.

[23]For more on precision farming, see Buchholz.

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