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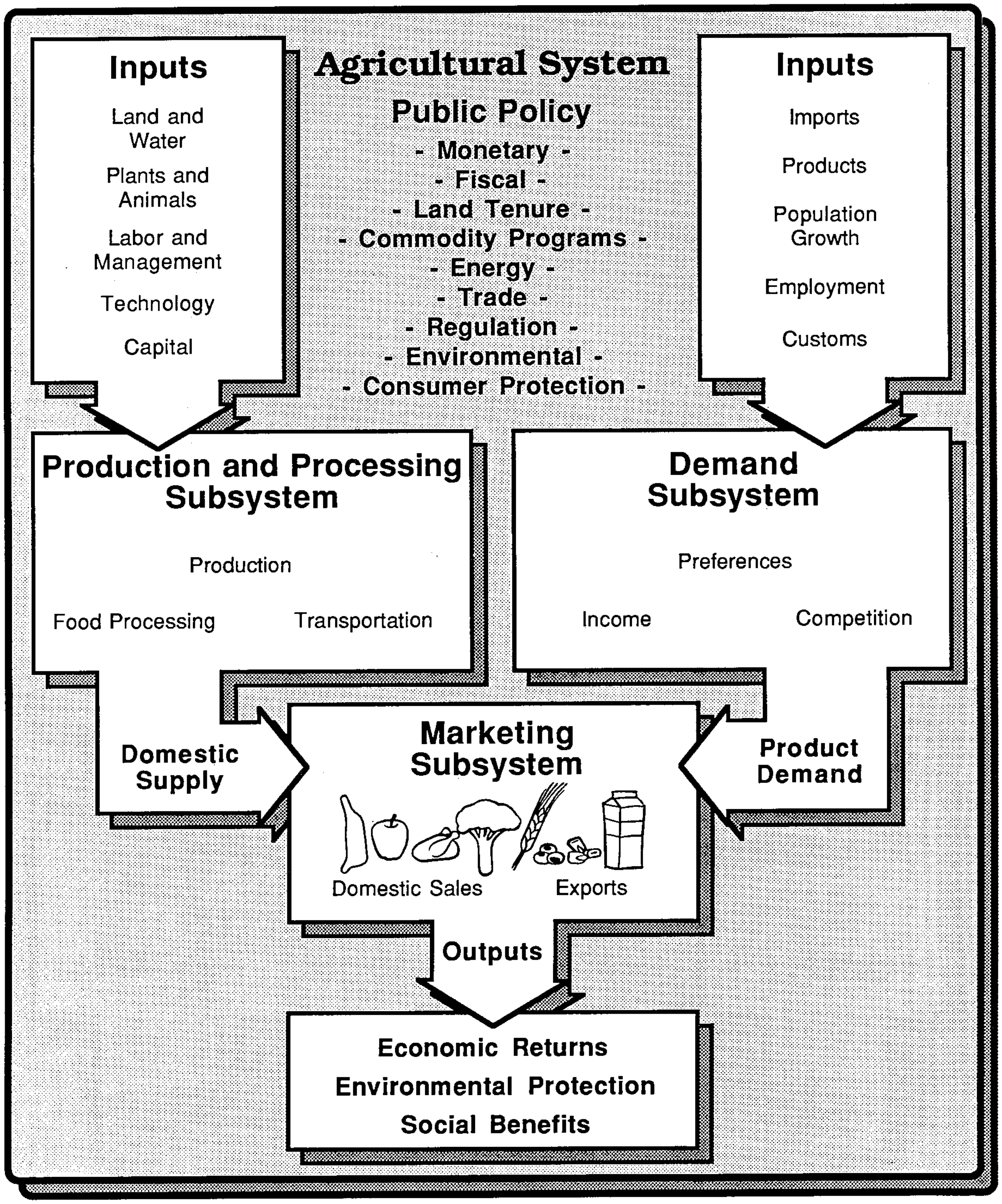
Long-Term Viability of U.S. Agriculture



Council for Agricultural Science and Technology

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The Council for Agricultural Science and Technology (CAST) is a nonprofit educational organization representing 28 member scientific societies, 5,000 individual, 150 company and nonprofit sustaining, and 15 associate society members. CAST's board of directors is composed of 50 representatives of the scientific societies and individual members.

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The primary mission of CAST is the publication of task force reports written by scientists representing many disciplines. The national concerns committee screens ideas from many sources and recommends to the board certain topics for approval as task force projects. Volunteer, multidisciplinary task forces of scientists nominated by members societies and others are recruited to serve as task force members. Careful selection of topics, diverse writing groups, and active participation by all task force members assures Congress, the media and the public that a balanced statement on agriculturally related social, economic, environmental, energy, and health issues results.

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Cover Illustration

Cover illustration of the complex agroecological, economic, environmental, social, and political components interacting in U.S. agricultural production and marketing systems. By Rex D. Heer, Iowa State University, Ames, Iowa. Illustration adapted from H. A. Fitzhugh and E. K. Byington. 1978. Systems approach to animal agriculture. *World Animal Review* 27:2-6.

A Statistical Profile

U.S. Agricultural Industry = Largest U.S. Industry

Farm assets = $771 billion on December 31, 1985

Food and fiber = 17.5% total gross national product in 1985

Agriculture = largest U.S. employer (21 million people)

—2.18 million farms with 2.7 million workers
- 59.8% sold < $20,000 worth of farm products/farm
- 10.6% sold $20,000 to $40,000 worth of farm products/farm
- 15.2% sold $40,000 to $100,000 worth of farm products/farm
- 9.8% sold > $100,000 worth of farm products/farm

—18.3 million other agricultural workers including
- Meat and poultry industry = 370,000 people = $4.5 billion payroll
- Dairy industry = 162,000 people = $1.6 billion payroll
- Baking industry = 215,000 people =$2.1 billion payroll
- Food processing plants = 280,000 people = $2.8 billion payroll
- Cotton mills and finishing plants = 145,000 people = $1.6 billion payroll (U.S. Department of Agriculture, 1987)

Table P1. United States land ownership and use in 1982 (U.S. Department of Agriculture, 1987)

Type of land	Acres (millions)	Percentage of total
Federal land	404	21
Non-federal land	1,498	79
Total land area	1,902	100

Table P3. Percentage of farms, land in farms, and average size, by economic class, United States, June 1, 1985-86 (U.S. Department of Agriculture, 1987)

Economic Class Gross Value of Sales	Farms (Percent of Total)		Land (Percent of Total)		Average Size of Farms (Acres)	
	1985	1986	1985	1986	1985	1986
$ 1,000-$ 2,499	25.1	26.2	3.8	4.0	67	70
$ 2,500-$ 4,999	14.3	13.9	3.6	3.3	112	108
$ 5,000-$ 9,999	11.8	12.0	4.6	4.7	176	178
$ 10,000-$ 19,999	10.7	10.7	6.8	7.2	283	306
$ 20,000-$ 39,999	10.1	10.1	9.4	10.9	417	491
$ 40,000-$ 99,999	14.2	13.3	24.3	20.4	760	698
$100,000-$249,999	9.7	9.5	25.5	25.8	1,172	1,235
$250,000	4.1	4.3	22.0	23.7	2,419	2,507
Total	100.0	100.0	100.0	100.0	446	455

Table P2. Non-federal use of land in the United States, excluding Alaska, in 1982 (U.S. Department of Agriculture, 1987)

Type of land	Acres[a] (millions)	Percentage of total
Cropland	421	28
Pastured land	133	9
Rangeland	406	27
Forest land	394	26
Small water areas	10	1
Urban, built-up, and transportation areas less than 10 acres in size	74	5
Other land	60	4
Total land area	1,498	100

[a]Does not include 14 million acres of non-federal land in Alaska.

Table P4. Number of farms and land in farms, United States (U.S. Department of Agriculture, 1987)

Year	Number of farms (Thousands)	Acres of land in farms (Thousands)	Average size of farms (Acres)
1981	2,434	1,034,190	425
1982	2,401	1,027,795	428
1983	2,370	1,024,195	432
1984	2,328	1,019,378	438
1985	2,275	1,014,383	446
1986[a]	2,214	1,007,363	455

[a]Preliminary.

Table P5. Indexes of total farm input and major input subgroups (1977 = 100) (U.S. Department of Agriculture, 1987)

Year	Total inputs			Farm labor[c]	Farm real estate[d]	Mechanical power and machinery[e]	Agricultural chemicals[f]	Feed, seed and livestock purchases[g]	Taxes and interest[h]	Miscellaneous[i]
	All	Non purchased[a]	Purchased[b]							
1920	95	198	37	485	105	27	5	23	62	65
1930	99	195	43	463	104	34	6	27	76	60
1940	97	175	50	417	107	36	9	39	74	57
1950	101	166	60	309	109	72	19	58	83	63
1960	98	131	74	206	103	83	32	77	95	77
1970	97	107	88	126	105	85	75	96	102	89
1980	103	98	107	92	103	101	123	114	100	96
1981	102	97	107	90	103	98	129	108	99	108
1982	99	95	103	87	103	94	118	106	99	114
1983	95	91	96	79	101	89	105	106	99	110
1984[j]	96	89	103	80	99	88	120	106	95	122

[a]Includes operator and unpaid family labor, and operator-owned real estate and other capital inputs. [b]Includes all inputs other than nonpurchased inputs. [c]Includes hired, operator, and unpaid family labor. [d]Includes all land in farms, service buildings, grazing fees, and repairs on service buildings. [e]Includes interest and depreciation on mechanical power and machinery repairs, licenses, and fuel. [f]Includes fertilizer, lime, and pesticides. [g]Includes nonfarm value of feed, seed, and livestock purchases. [h]Includes real estate and personal property taxes, and interest on livestock and crop inventory. [i]Includes such things as insurances, telephone, veterinary fees, containers, and binding materials. [j]Preliminary.

Table P6. Farm production expenses (in billions of dollars)[a] (U.S. Department of Agriculture, 1987)

Major items	1964	1969	1974	1979	1982	1985
Purchased feed	5.5	7.1	14.5	19.3	21.7	19.6
Purchased livestock	2.4	4.2	5.1	13.0	9.7	9.0
Repair and operation	3.9	4.5	6.7	7.3	7.7	7.5
Capital consumption	4.9	6.6	10.5	19.3	23.9	21.1
Fertilizer and lime	1.9	2.3	6.1	7.4	8.0	6.9
Short-term interest	1.0	1.4	2.9	6.9	11.3	8.8
Mortgage interest	1.0	1.6	2.8	6.2	10.5	9.9
Property taxes	1.8	2.5	3.1	3.9	6.4	6.4
Labor	3.5	4.2	6.1	9.0	10.2	10.4
Total Production Expenses	31.6	42.1	71.0	123.3	140.7	136.1

[a]As of December 31, includes farm households.

Table P7. Agricultural productivity (U.S. Department of Agriculture, 1987)

Year	U.S. population (July 1) (millions)	Index of total farm output (1977- 100)	Index of output per work hour (1977 - 100)
1930	123.1[a]	43	9
1940	132.1[a]	50	12
1950	151.7	61	19
1955	165.3	69	26
1960	180.8	76	37
1965	194.4	82	52
1970	205.1	84	66
1975	216.0	95	89
1976	218.0	97	94
1977	220.2	100	100
1978	222.6	104	108
1979	225.1	111	119
1980	227.8	104	113
1985	239.3	119[b]	155[b]

[a]Includes 50 States
[b]Estimated

Table P8. Farmers' assets, debts, and equity (in billions of dollars)[a] (U.S. Department of Agriculture, 1987)

Item	1940	1950	1960	1970	1980	1985
Assets:						
Real estate	34.4	89.5	138.5	223.2	846.6	607.5
Physical assets other than real estate	15.6	48.7	54.5	78.8	219.0	206.6
Financial	4.7	16.0	17.8	24.0	42.8	52.7
Total	54.8	154.3	210.9	326.0	1,008.3	866.8
Debts:						
Real estate	6.5	6.1	12.8	30.3	95.8	105.4
Nonreal estate	3.3	6.1	12.0	22.3	81.6	82.6
CCC	0.6	0.8	1.4	1.9	5.0	16.9
Total	10.5	13.1	26.2	54.5	182.3	204.9
Equity	44.3	141.3	184.7	271.5	926.0	661.9

[a]As of December 31, includes farm households.

Table P9. The amount of food the average factory worker's hourly pay would buy (U.S. Department of Agriculture, 1987)

Food item	1950	1985
White bread	10.1 lbs.	15.5 lbs.
Broilers	2.5 lbs.	11.2 lbs.
Milk	8.0 qts.	15.1 qts.
Fresh potatoes	32.7 lbs.	41.2 lbs.
Eggs	2.4 doz.	10.7 doz.
Pork	2.7 lbs.	5.3 lbs.

Table P10. Cash receipts from farm marketings, all states, 1985 (in millions of dollars) (U.S. Department of Agriculture, 1987)

State	Total	Livestock and livestock products	Crops	The two leading commodities ranked by cash receipts 1.	2.
Alabama	2,077	1,301	776	Broilers	Cattle, Calves
Alaska	26	8	18	Grnhse. Nursery	Dairy Products
Arizona	1,529	702	827	Cattle, Calves	Cotton
Arkansas	3,280	1,825	1,455	Broilers	Soybeans
California	13,970	4,165	9,805	Dairy Product	Grnhse. Nursery
Colorado	3,164	2,019	1,145	Cattle, Calves	Wheat
Connecticut	316	206	110	Eggs	Dairy Products
Delaware	490	352	137	Broilers	Corn
Florida	4,741	1,015	3,726	Oranges	Grnhse. Nursery
Georgia	3,327	1,727	1,600	Broilers	Peanuts
Hawaii	540	83	458	Sugar Cane	Pineapples
Idaho	2,063	862	1,200	Cattle, Calves	Potatoes
Illinois	7,768	2,063	5,704	Corn	Soybeans
Indiana	4,597	1,728	2,869	Corn	Soybeans
Iowa	9,201	4,811	4,390	Corn	Hogs
Kansas	5,741	3,264	2,478	Cattle, Calves	Wheat
Kentucky	2,871	1,352	1,519	Tobacco	Horses, Mules
Louisiana	1,460	491	968	Soybeans	Cotton
Maine	378	250	127	Dairy Products	Eggs
Maryland	1,148	770	278	Broilers	Dairy Products
Massachusetts	389	124	265	Grnhse. Nursery	Cranberries
Michigan	2,850	1,231	1,619	Dairy Products	Corn
Minnesota	6,472	3,370	3,102	Dairy Products	Corn
Mississipi	2,136	1,010	1,126	Cotton	Broilers
Missouri	3,668	1,930	1,738	Soybeans	Cattle, Calves
Montana	1,207	802	405	Cattle, Calves	Wheat
Nebraska	7,206	4,113	3,093	Cattle, Calves	Corn
Nevada	222	144	78	Cattle, Calves	Hay
New Hampshire	107	71	36	Dairy Products	Grnhse. Nursery
New Jersey	591	144	447	Grnhse. Nursery	Dairy Products
New Mexico	1,086	718	369	Cattle, Calves	Dairy Products
New York	2,564	1,845	719	Dairy Products	Grnhse. Nursery
North Carolina	3,914	1,934	1,980	Tobacco	Broilers
North Dakota	2,746	686	2,060	Wheat	Cattle, Calves
Ohio	3,940	1,511	2,430	Corn	Soybeans
Oklahoma	2,664	1,726	938	Cattle, Calves	Wheat
Oregon	1,778	622	1,156	Cattle, Calves	Wheat
Pennsylvania	3,150	2,184	966	Dairy Products	Cattle, Calves
Puerto Rico					
Rhode Island	63	13	49	Grnhse. Nursery	Dairy Products
South Carolina	1,033	415	618	Tobacco	Soybeans
South Dakota	2,980	1,903	1,076	Cattle, Calves	Wheat
Tennessee	2,057	1,000	1.057	Cattle, Calves	Dairy Products
Texas	9,298	5,441	3,857	Cattle, Calves	Cotton
Utah	548	409	138	Cattle, Calves	Dairy Products
Vermont	384	352	32	Dairy Products	Cattle, Calves
Virginia	1,627	1,004	623	Dairy Products	Cattle, Calves
Virgin Islands					
Washington	2,797	932	1,865	Wheat	Dairy Products
West Virginia	241	192	50	Cattle, Calves	Dairy Products
Wisconsin	5,111	4,100	1,012	Dairy Products	Cattle, Calves
Wyoming	589	479	110	Cattle, Calves	Sheep, Lambs
United States	142,103	69,401	72,702		

Table P11. Historical summary: Value of U.S. foreign trade and trade balance, calendar years 1940-86 (U.S. Department of Agriculture, 1981; 1986c)

Year	U.S. EXPORTS Agricultural	Nonagricultural (Million dollars)	Total	Percent agriculture	U.S. IMPORTS Agricultural	Nonagricultural (Million dollars)	Total	Percent agriculture	TRADE BALANCE Agricultural	Nonagricultural (Million dollars)	Total
1940	517	3,417	3,934	13	1,284	1,257	2,541	51	−767	+2,160	+1,393
1950	2,873	7,269	10,142	28	3,987	4,756	8,743	46	−1,114	+2,513	+1,399
1960	4,832	15,543	20,375	24	3,824	11,190	15,014	25	+1,008	+4,353	+5,361
1970	7,259	35,331	42,590	17	5,770	33,986	39,756	15	+1,489	+1,345	+2,834
1980	41,256	175,336	216,592	19	17,366	222,577	239,943	7	+23,890	−47,241	−23,351
1986	26,046	180,318	206,364	13	21,051	347,760	368,811	6	+4,995	−167,442	−162,447

Preface

The future course of American agriculture has been widely debated for years. The late 1980s are no exception. The combination of the farm crisis, low prices for major commodities, some shift in land ownership, and mounting environmental concerns has caused the public and policymakers to question the future of U.S. agriculture. Concerns about structure and long-term viability are valid issues to debate locally, nationally, and internationally. The interdependence of the world's countries on food supplies obliges the United States, a major provider of selected food commodities, to evaluate and maintain its capability to produce essential foods or food ingredients. Yet, at the same time, the United States must protect its environment and natural resource base for use by future generations.

At the 1986 summer meeting, the CAST Board of Directors approved a task force project under the general heading of "Capitalization of Agriculture and the Long-Term Sustainability of Agriculture." Following the directors' actions, a group of nine persons representing academia, government, and industry met in Washington, D.C. to explore this matter further. Discussion centered on some trouble spots: farmers with debt-to-equity ratios greater than 40 percent, excess acres in production, potential water shortages, water quality, and soil erosion. The concensus of this group was that CAST should produce a report that addressed issues affecting the viability of U.S. agriculture into the 21st century.

Under the chairmanship of Luther G. Tweeten, of The Ohio State Universtiy, the majority of the members of a 22-person task force met in St. Louis on March 6 and 7, 1987. Prior to the meeting Tweeten had distributed an outline for task force members to evaluate and revise. The purpose of the meeting was to develop a detailed outline, establish a calendar of dates by which work on the report would be completed, and select subgroups to be responsible for writing the first draft of sections of the report.

After the report had been written, representatives of the American Society of Animal Science began searching for ways to strengthen the "animal" component of the report. To accommodate these and other interests, a group of six persons met at the University of Nebraska-Lincoln on February 18, 1988 to decide how the report could be revised and updated. Additions to the text and inclusion of separate tables on the scope of U.S. agriculture gave an additional focus to the report. Tabulated material gives the reader a broad statistical overview of U.S. agriculture.

This report is being distributed to members of Congress, the U.S. Department of Agriculture, the Environmental Protection Agency, the Food and Drug Administration, the Agency for International Development, Office of Technology Assessment, Office of Management and Budget, media personnel, state legislatures who have asked to receive CAST publications; and to institutional members of CAST. Individual members may receive a copy upon request within one year of publication. The general public may purchase copies at $4.00.

On behalf of CAST, we thank the task force members, especially Dr. Tweeten, who gave of their time and talents to prepare this report as a scientific contribution to Congress and the general public. We also thank the employers of the task force members, who made the time of the members available at no cost to CAST. The members of CAST deserve special recognition because the unrestricted contributions they have made in support of the work of CAST have financed the preparation and publication of this report.

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Contents

1. Highlights

A long-term viable agriculture is defined as one providing safe, abundant, and nutritious food supplies at a reasonable cost while preserving the environment and the beauty and wholesomeness of our rural heritage. Long-term viability has economic (including technology and productivity), environmental (including the natural resource base), and social (family farm, rural community) dimensions. Each dimension raises serious issues for public policy.

• The long-term viability of American agriculture cannot be taken for granted. To be sure, the United States has vast natural resources and favorable climate for agriculture, great managerial and other human resource capabilities in its farmers, and a scientific, transportation, processing, marketing, and information infrastructure that is the envy of the world. But without supportive macroeconomic, science, education, trade, resource, and environmental policies, the competitive advantage of agriculture can be lost at great cost to farmers and consumers at home and abroad.

• The pace of agricultural productivity growth has slowed in recent decades, for individual commodities and in aggregate. For example, corn yields fell from an annual growth rate of 4.3% in 1950 to 2.5% percent in 1985 to a projected 1.2% percent to year 2000 — the latter estimate from a panel of agricultural scientists assembled by the Office of Technology Assessment (OTA) of the U.S. Congress. An exception was for dairy (milk production per cow) which was projected to increase sharply. New biotechnologies are cause for optimism but not complacence regarding future productivity gains. Public concerns over health and environmental hazards from biotechnology and its products may result in policies which slow productivity gains from dairy as well as other farm enterprises.

• The principal economic problems of agriculture in the past decade have not come from lagging or advancing technology (and productivity), from weather, or from predatory trade policies of competitors. Rather agriculture has been victimized by "man made" unfavorable monetary and fiscal policies. Erratic and overly expansionary monetary policies in the 1970s brought excess debt, inflation, unsustainable demand expansion, and an oversized agricultural plant. Large full-employment federal deficits in the 1980s brought high real interest and exchange rates, falling land prices and exports, and farm financial stress. Sound monetary and fiscal policies are as essential as sound technology, trade, natural resource, and environment policies to ensure the long-term viability of agriculture.

• Reliance on technology is not a substitute for careful stewardship of the resource base. Current excess production capacity offers opportunity for millions of acres of cropland that is erosion-prone or irrigated with nonrenewable groundwater to be shifted to grass, trees, recreation, or other soil and water conserving uses. This report suggests beneficial ways to use the Conservation Reserve Program and a proposed cropland easement program to conserve natural resources.

• World reserves of phosphate and potash are adequate for several decades but U.S. reserves are depleting rapidly. Known world phosphate reserves are adequate for only about 60 years and known plus anticipated reserves are adequate for only approximately 90 years based on usage increasing 3.6% annually as projected by the U.S. Bureau of Mines and Geological Survey. Reserves do not run out; they become uneconomic to utilize. But depletion of reserves with today's technology would mean food shortages and higher food prices. Nitrogen is abundant in its natural state but requires a large amount of rapidly depleting fossil fuels to convert into commerical fertilizer. Public policy needs to address fossil fuel and phosphate depletion concerns and the obligation to devise technologies that permit low-cost agricultural production using less commercial fertilizer through biotechnologies such as plants with nitrogen-fixation capabilities.

• Groundwater contamination from commercial fertilizers and pesticides is of growing concern for many regions of the U.S. These concerns must be addressed with appropriate analysis and public policy. Too little is known at this time of the costs and benefits of alternative responses to the problem to make sound public policy.

• Reduced numbers of family farms, which have a weak financial or managerial base, do not threaten food supplies or the long-term productivity of agriculture but two policy options are prominent if society through the political process determines that policy intervention is appropriate. The first is to provide public programs of counseling, job information, training, and financial assistance for mobility of these families into alternative employment. The second option is to target direct payments to such families, while phasing out commodity programs for others, if the public deems full-time family farms are an essential part of our heritage and is willing to pay the cost of preserving them.

• The best strategy for economic viability is *flexibility* to respond to future food and fiber abundance or shortfall because of inability to predict accurately the future. Projections of future food and fiber supply-demand balance are unreliable and often conflict. Where inevitable mistakes are made, it is better to err on the side of adequate investments in productivity to maintain competitive advantage and continue to provide consumers the benefit of quality food at reasonable prices.

• Economic viability ultimately depends on investments in human resources, science, technology, and wise use of soil, water, and other natural endowments. By investing to maintain its leadership in science, especially in basic and applied research, including biotechnology, the U.S. can be at the forefront of productivity advances enhancing the nation's competitive position, preserving the environment, and providing low-cost food — of special benefit to low income people.

• Regarding social viability of agriculture, family farm numbers and farm population are projected to continue to decline at approximately 2% per year. This rate, near that of the 1980s, continues despite massive spending on commodity programs ostensibly designed to preserve family farms. The Task Force concluded that mandatory production controls, high rigid price supports, and maintenance of an oversized agricultural production plant is an inappropriate response to these problems. The future viability of the adequate size, well-managed commerical farms and the part-time smaller farms is not in doubt. The future is much in doubt, however, for full-time family farms lacking a strong financial or managerial base, too small to realize economies of size, and too demanding of labor and management for the operator and family to earn substantial off-farm income.

2. Summary

This report (1) inventories the current state of knowledge, (2) analyzes past trends and long-term outlook, and (3) lists policy options for the long-term economic, environmental, and social viability of U.S. agriculture. Economic viability depends on supply-demand balance, prices, comparative advantage, commodity programs, and technology. Environmental viability refers to the utilization and maintenance of natural resources for use in agriculture and protection of land, air, water, and the resulting food products from contamination due to agricultural practices. Social viability deals with the ability of the farming industry to sustain its unique moral and social contributions to local communities and to society as a whole. These dimensions of viability overlap but are treated separately for expository purposes.

Economic Viability

The best projection is that supply will slightly outrun demand beyond the year 2000, bringing lower real farm prices, the need for exodus of farm resources, and absence of pressure to bring new land into cultivation.

U.S. agricultural exports are likely to grow at rates at least as high as world agricultural export growth rates after losing ground in the 1980s. Export projections, although well below growth rates of exports in the 1970s, do not indicate loss of U.S. comparative advantage. The basic advantages of American agriculture remain intact. Lower input prices and exchange rates along with pressure to earn foreign exchange to service international debt will assist farm exports in the intermediate run.

The best guess is that no *strong* upward or downward trend will dominate the supply-demand balance affecting real farm and food prices. There will be considerable annual and cyclical instability around the long-term trend. For public policy purposes, that instability is a greater immediate concern than the overall trend. A viable agriculture can adjust to persistent high prices or persistent low prices within the range of expected trends, but it has great difficulty adjusting to persistently unstable prices.

Even the best projections of future supply and demand are subject to large error and must be interpreted with caution. Because of this inability to predict the future, the best strategy for economic vitality is *flexibility* to respond to abundance or shortfall. Where inevitable mistakes are made, it is better to err on the side of investment and productivity to maintain comparative advantage and provide consumers with the benefit of continued reasonable food prices. To err on the side of too little investment in science and conservation in a global economy robs agriculture of its economic vitality and domestic consumers of their chance for adequate quantity, variety, and quality of food supplies at reasonable prices.

Economic viability depends ultimately on investments in human resources, science, technology, and wise use or protection of soil, water, and other natural endowments. By maintaining its leadership in science, especially in basic and applied research including the new biotechnology, the U.S. can be at the forefront of productivity advances enhancing the nation's competitive position, helping to preserve the environment, and providing low-cost food — a special benefit to low-income people. Quality, variety, and safety of foods can continue to improve. The farming industry is expected to maintain its economic vitality because farm prices are expected to decline at rates no greater than compensated by lower real production costs made possible by productivity gains.

Environment and Natural Resource Viability

Given appropriate public policy outlined herein, the soil and water resources in the United States are adquate for future agricultural viability. If demands for food and fiber increase, cropland can be expanded and utilized more intensively. If cost/price relationships are favorable, new technologies will be developed to increase yields and conserve land and water. Air quality will be affected by technological and policy changes predominantly beyond the control of agriculture. Reliance on technology is not a substitute for careful stewardship of the resource base but the Task Force is optimistic that emerging technologies can enable the nation to meet food and fiber needs at lower real cost while improving the quality of the environment.

The U.S. food and agricultural system is a hierarchial progression, an aggregation and integration of millions of crop and livestock ecosystems (enterprises) into farms, then communities, commodity groupings, regions, states, and finally the total dynamic national complex. Two major characteristics of integrated agroecosystems give strength and support to the long-term sustainability of the overall food and agricultural system. These are (1) complementarity and synergism of enterprises for increased efficiency of output, and (2) the buffering effect among the components wherein as one changes the others adjust accordingly.

An excellent example of the complementarity of enterprises is seen in the rearing of beef cattle on grazing land that would otherwise offer little productivity. Cattle from these grazing lands move into feedlots and provide one outlet for large quantities of grain with the end result being a valuable contribution to the human diet. Animal waste returned to the soil provides a useful input for crop production. By the same token, crop refuse and by-products of food processing can be converted into animal feeds that further add to this synergy between plants and animals. Attention to the interrelationships and interactions among crop and livestock agroecosystems offers significant opportunity for enhanced viability of the total food and agricultural system.

While we currently have some reserve capacity in cropland, a strong conservation program must continue. Loss of topsoil to wind and water erosion continues to cause concern. Alternatives to petroleum such as biological sources of nitrogen and pest control must remain on the agenda for research and development.

In summary, the U.S. has a natural resource base to sustain a viable agricultural industry, but it is critical that new technologies and sound conservation practices be developed and employed to extend this viability to the long term.

Social Viability

A changing agriculture affects local institutions in significant ways. Exodus of farm families may cause the closing of schools, the decline of rural churches, fewer medical facilities, and a shrinking clientele for local businesses. As farms increase in size and decrease in numbers, farm families purchase goods and services in larger communities. Communities also influence farms. For example, for unprofitable farmers who wish to maintain farming as a life style, or for beginning farmers unable to service cash-flow requirements, off-farm income is necessary to maintain the farming unit while achieving an acceptable standard of living for the family. In a growing number of instances, the community influences the viability of local agriculture as much as agriculture influences the community.

The family farm is a remarkably resiliant institution and will be around for generations to come. The vitality of agriculture is not uniquely tied to any one institutional form. Prospective changes in family farm types and numbers do not threaten food supplies or undermine the nation's social and democratic fabric.

Conclusions and Policy Options

Estimates of comparative advantage and projections of future supply-demand trends are inadequate to appraise long-term viability of agriculture. Unfolding events quickly outrun our poor powers to predict. The long-term viability of U.S. agriculture ultimately rests not with our ability to rigidly plan or shape a knowable future, but instead rests with a public policy of resiliency and flexibility to respond to an unknowable future.

The United States' international trade position of the 1980s is unsustainable. The nation is consuming much more than it produces and has become the world's largest debtor. That debt will be serviced by exports. Because of favorable natural and human resources, infrastructure (including the agribusiness sector), and scientific base, U.S. agriculture can be an important exporting industry. Average labor productivity and total factor productivity have been increasing faster in agriculture than in other industries. Agriculture is among the nation's most capital and research intensive industries—a "high technology" sector capable of meeting world competition. Public policies listed below can help to ensure the long-term vigor and stamina of agriculture.

1. *A viable agriculture requires a strong effort in science and technology.* The single most important ingredient to ensure long-term viability of agriculture is continuing investment in science and technology. This investment will maintain comparative advantage and continue to earn foreign exchange to pay for imports. New biological and informational technologies offer opportunity for substantial enhancement in agricultural proficiency, reduction in farm production cost, protection of the environment, and generation of new market opportunities. Public policy must support and not restrict development of these new technologies.

2. *New modes for coordinating basic and applied science and technology are needed.* Biology offers exciting prospects but coordination of such science is a challenge. More and more agricultural basic research will originate from public (and private) research establishments outside the colleges of agriculture and,

indeed, outside of the land-grant universities and Agricultural Research Service system. Joint research ventures between colleges of agriculture and colleges of arts and sciences, colleges of medicine, colleges of veterinary medicine, and with private universities are possible responses.

3. *Agricultural extension's role will change.* The new technology of information gathering, exchange, and processing will force Cooperative Agricultural Extension into new roles and away from the researcher-specialist-county agent-farmer hierarchy that has characterized technology transfer. Private industry is increasing its focus on technology transfer to the farmer. This trend is likely to continue and expand as firms compete on the service and on the product side. Agricultural extension can view this change either as the entrance of a new competitor or as the opportunity to expand its clientele to include private industry consultants and industry representatives.

4. *A flexible policy for science, education, environmental protection, and commodity supports is essential.* Least viable is an agricultural policy of high rigid price supports and mandatory production controls. High walls of protective tariffs would insulate farmers from world competition but would also bring an absolutely declining farming industry with productivity far outrunning a lethargic domestic demand. Such an agriculture would not earn foreign exchange to service international debt or to purchase needed imports.

5. *Public policies for a viable agriculture need not interfere with the opportunities for commercial farmers to compete in international markets.* It is neither possible nor desirable to totally separate policies keeping agriculture viable environmentally and economically from policies to accomplish social objectives such as to protect family farms and rural communities. But caution is suggested. For example, serving social objectives by focusing public research uniquely on small farms (accounting for most farms but a small portion of all farm resources and output) is likely to forego benefits from safer food at low cost to society and benefits from foreign exchange earned because of ability to compete in international markets.

6. *A strong program of training and mobility assistance is complementary with policies to more aggressively enhance productivity growth in agriculture.* Some farm operators and their families will be unable to maintain the management skills and the technological pace necessary to compete in a dynamic economic environment. Some farm families who fall behind will be unable to form an economic unit or find satisfactory means of livelihood because of misfortune such as illness, disability, an unexpected turn of weather or prices, and a host of other factors simply labeled bad luck. The public has a role in providing a safety net for such families. Commodity programs and credit programs alone do not meet their needs.

7. *Education and vocational programs for future farm operators can be revised.* The modern day commercial farm requires a high level of business acumen, portfolio-management capabilities, and risk-management skills comparable to those qualified to run a sizable non-farm business. A very high level of managerial ability is required. A college education, even a Masters degree in Business Administration or Agribusiness is viewed as extremely useful. The vocational agriculture program in high school has served youth well over the years, and is especially important in establishing a sense of pride, responsibility, citizenship, and leadership. However, some changes are necessary to prepare future farm operators.

8. *Sound macroeconomic and trade policies contribute to the long-term economic, social, and environmental vitality of agriculture.* Agriculture inevitably will face instability because it is subject to the weather and biological processes of nature. Of special concern are the growing man-made sources of variability manifest in inflation, in high real interest rates, and in overvalued exchange rates. Rising oil prices combined with erratic and overly expansionary money and credit expansion worldwide led to high inflation in the late 1970s and to the counter-cyclical world recession in the early 1980s. Large U.S. federal budget deficits in a full-employment economy contributed to high real interest and exchange rates and to financial crisis on U.S. farms and in developing countries (especially in Latin America) in the 1980s. The economic health of U.S. family farms in particular and U.S. agricultural viability in general will be enhanced and personal trauma reduced by sound monetary-fiscal policy. High real interest rates discourage long-term investment in conservation to preserve the environment and intermediate-term investment in commodity buffer stocks to reduce price instability.

9. *Improved means to deal with farm and food instability can reduce farm economic stress while providing food supplies at less cost to consumers and taxpayers.*

Even the best of monetary, fiscal, and trade policies will not eliminate instability. Although adequately-sized, well-managed farms have earned returns at least comparable to what their resources would earn elsewhere on the average over the past three decades, still economic outcomes even on efficient farms tend to be highly unstable. Producers need education and encouragement to make greater use of private risk-shifting strategies including insurance, the futures market, and put-call options.

10. *More complete information gathering, analysis, and dissemination are critical to sound decisions for a viable agriculture.* The public properly is concerned over the impact on food safety and quality of modern farming methods and of agricultural chemicals. The appropriate response by the agricultural community and others is to search for and report the truth, insofar as it can be known, and support appropriate private and public actions to promote the general welfare. Full disclosure, accessed information, and increased research are essential in resolving issues of food safety. Acceptable trade-offs between risk and benefit will be determined by consumers and the political process. Risk-benefit analysis, though in a formative stage and flawed by inadequate data, potentially has much to offer.

11. *Informed producers can become a more effective force for constructive change.* Farm families may be exposed to agricultural chemicals residue contamination in drinking water and food. If farmers are to play a constructive role in protecting their own welfare and the environment, they as well as society must be well informed of risks from pesticides, antibiotics, and other adventitious additives. Improved programs are needed to educate farmers about management practices to reduce the environmental and health risk of chemical use.

Many of the environmental impacts of agriculture affect third-party interests outside of agriculture. The traditional voluntary U.S. Department of Agriculture (USDA) approach to soil and water management may not be acceptable unless a high compliance rate can be demonstrated. Integration of environmental issues into basic farm policy has merit.

12. *Changes in farm land retirement programs can reduce social cost and enhance long-term agricultural viability.* Long-term operation of an expensive price support program is in the best interest neither of farmers nor society, but the Conservation Reserve Program (CRP) can reduce soil and water loss while contributing to wildlife habitat, recreation, reserve production capacity, and farm income. The several possible changes listed below are designed to augment the attractive multiple long-term benefits of CRP for a viable agriculture. These options deserve consideration but require in-depth analysis (which the Task Force did not have time nor resources to undertake) before implementation.

—The Conservation Compliance Provisions could be moved forward or further CRP expansion delayed until conservation compliance becomes operational so that the two features can work together.

—An alternative or supplement to the above option would be cropland easements on highly erodible land. The owner could use the land for grazing, haying, wildlife habitat, recreation, or other uses under an approved conservation plan, but not for cropland.

—Increase the proportion of land eligible for the CRP or easements in counties with severe erosion problems; at the same time allow grazing and haying of additional land in the programs to reduce unfavorable economic impacts on local communities and lower bid costs to the government.

—Expand the CRP or easements on use of nonrenewable groundwater supplies for irrigation on a county-wide basis. Pumping needs to be halted over a considerable area but dryland cropping could be continued to help rural communities remain viable. In this and other cases where grazing and haying are permitted, attention needs to be paid to safeguard the livestock industry from too rapid an expansion of supply.

—CRP or easements could place greater emphasis on controlling erosion in criteria for acceptance of bids. A premium could be paid to obtain the most erosion-prone cropland in CRP. Holding reserve production capacity, wildlife habitat, and recreational lands would be important but secondary objectives.

13. *If the public deems that farm-based rural communities need economic support, limited public funds will do more to help people in those communities by providing human resource investments in schooling and vocational-technical education rather than in subsidizing farmers merely to aid rural communities.* A small proportion of rural communities and rural people today depend on farming for an economic base. A highly diversified economic base assures that the future of rural communities is secure although many communities will decline while others flourish.

14. *U.S. foreign economic assistance can be expanded to improve well-being of people in developing countries while stimulating long-term U.S. farm export markets.* U.S. foreign economic assistance can expand demand for U.S. farm exports while improving quantity, quality, and stability of food supplies in developing countries. As nations progress economically under appropriate economic assistance, demand expands for meat, a source of high-quality protein. U.S. technical assistance can play a critical role in overcoming constraints to expansion of livestock, including animal diseases, pests, nutritional problems, and product marketing, distribution, and storage problems in these potential markets.

Many nations are committed to self-sufficiency in domestic food production. A more realistic goal is food security, defined as being assured of adequate food supplies. In many instances, importation of some food and feed allows most efficient use of resources and highest living standards. Higher income allows countries to afford imports when local production fails. An appropriate U.S. stance is to build the reputation of being a reliable supplier and to encourage and strengthen use of the International Monetary Fund's cereal program. The cereal program addresses the instability problems by assuring less developed countries the financing for import of cereals when domestic crops fail or international prices soar.

In conclusion, this report provides a vision of qualified optimism for the future of American agriculture. The nation is endowed with the greatest expanse of rich land in the world located in a favorable climate, the most vigorous public and private infrastructure (including private agribusiness industry), and has a population with a desire and spirit to make wise use of resources. With the help of market incentives and responsive and supportive public policies, American agriculture will remain viable in the long run.

Part-time small family farms are becoming more numerous. Midsize family farms with able management and substantial equity passed from generation to generation have remarkable resilience. Hence, the future of the family farm is not in doubt.

The future is in doubt, however, for full-time family farmers lacking a strong financial or managerial base, too small to realize efficiency of large farms and too demanding of labor and management for operator and family to earn substantial off-farm income. The demise of such farms in no way threatens food supplies or other dimensions of a long-term viable agriculture, but two options are prominent. The first is to provide public programs to ease the transition of families to other forms of economic livelihood. The second is to provide targeted payments to such families if the general public deems such farms to be vital to our national heritage and is willing to pay the price of preserving them. Recent experience raises doubts whether payments can in fact be targeted efficiently or effectively. However, the above policies are preferred over commodity supply control and price support programs which distort incentives and interfere with ability of all farmers to compete in domestic and world markets for the sake of preserving a minority of marginal farms which are at risk.

3. Introduction

The nation's food and agriculture system is unique. It is more than just a means to provide today's daily bread. It is a treasured part of our national heritage. Its value cannot be measured in acres of soil or blades of grass alone any more than the Liberty Bell can be measured by the price of bronze.

Scope and Objectives

Recognizing and appreciating the spiritual and cultural value of agriculture does not preclude a rational examination of problems and opportunities in agriculture. A long-term viable agriculture will provide us and our posterity safe, abundant, and nutritious food supplies at reasonable cost while preserving the beauty and wholesomeness of our rural heritage. To do so, we must look ahead. That is the function of this Task Force.

Long-term viability of agriculture is divided into economic, environmental, and social dimensions although we recognize that these dimensions overlap. *Economic viability* of the food and agriculture system is apparent in a falling or constant long-term real price of food and fiber in relation to prices paid by farmer, prices paid by consumers for a composite of other goods and services, and by a declining share of consumers' income spent on food and fiber.[1] *Environment and natural resource viability* is apparent in maintenance of a high quality natural resource base for economic viability of agriculture, and protection of food products, land, air, and water from contamination due to faulty agricultural practices. *Social viability* means maintaining our rural heritage of family farms and rural communities in the long run.

These concepts raise many questions. Is agriculture viable as measured by ability to provide an adequate quantity, quality, and variety of safe food and fiber at reasonable cost over the long run? Does American agriculture have comparative advantage to compete in world markets? Are we husbanding our resources of land, air, water, and people? Is agriculture able to cover all costs of production without subsidies in a world market? Are new directions required in public policy, including that for research, extension, and education to ensure long-term viability of agriculture? This report attempts to answer these and other questions important to the future of food and agriculture in the United States.

The procedure is to:

1. Inventory the current state of knowledge.
2. Appraise past trends and analyze the long-term outlook.
3. List policy options to ensure long-term economic, environmental, and social viability of U.S. agriculture.

There is mounting evidence that a food cycle characterizes the world much as commodity cycles characterize agriculture in individual nations. One phase of the cycle begins when food shortages and high food prices send tremors throughout the world such as occurred with World War I, World War II, and in 1966-67 and 1973-74. This engenders a long-run outlook of rising real food prices, lagging food technology, and the need for food self-sufficiency. The results of frantic search for improved technology and a shift of resources into agriculture ushers in the second phase of the cycle. Characteristics of this second phase include excessive production relative to effective demand, food surpluses, protectionism, exporting of surpluses, and trade wars. General pessimism pervades producers and is apparent in expectations of chronic low real farm prices and of continuing excess production capacity. The world is now in that phase of belief in perennial excess production capacity and cornucopia. However, neither a world view of chronic surplus nor chronic shortage has been correct; each world view begets its opposite.

Excess farm production capacity, defined as United States' production capacity in excess of what the market will absorb at current prices given normal weather was 9% in 1986, the largest ever (Dvoskin, 1987, p. iv). This excess capacity (removed by government programs of acreage diversion, stock accumulation, and demand expansion) means that 9% of farm resources were in excess supply at 1986 prices. Some reserve capacity is desirable to cushion shocks to world food supplies but the current excess far exceeds needed levels (Eaton and Steele, 1976). Lower price supports are being used to decrease excess production.

This current general world food abundance relative to effective demand provides a cushion of food reserves and production capacity on which the nation can draw while adjusting to social and environmental needs. There is time to prepare for the next world food crisis. There is time to devise a policy for all seasons, recognizing that neither Pollyanna nor Cassandra provide

[1] Here the real price or cost includes government as well as consumer costs of food and agriculture.

lasting prognosis. There is time to conserve resources and to protect the environment so that the world is ready to respond to whatever needs arise. There is time to give careful attention to policies affecting the future of our farms and rural communities along with the people depending on them.

Conceptual Framework

There is concern with the long-term viability of agriculture because of concern for the well-being of people—not just of this generation but of generations to come. The well-being of people is increased by allocating resources where *social* returns are highest. Social returns include benefits accruing to society and not just to the farm, consumer, or agency immediately affected. If the public and private sectors allocate resources to where social payoffs are greatest, then the nation will be making the best use of resources; issues of whether food costs and land and water costs are rising or falling are of secondary importance. A viable agriculture providing safe, abundant, and nutritious food supplies at reasonable cost while preserving the beauty and wholesomeness of our rural heritage will follow naturally if resources are used properly. The market efficiently allocates resources and products where there is no significant divergence between private and social cost (benefits), where monopoly power does not intrude, and where people have access to opportunity. Successful agricultural and food systems the world over have harnessed the efficiency of the market, but it is important to recognize that the market alone will not bring allocations to assure the long-term viability of agriculture.

Public policies can supplement the market to assure long-term viability of agriculture. Some examples are listed below.

—One role for the public sector is to correct divergence between private and social costs (benefits). Soil erosion on Farm A frequently adds to sedimentation or other damage to "downstream" Farms B and C. Because Farm A does not bear the cost of downstream sedimentation, economic decisions which align incremental benefits with costs on Farm A in isolation will provide less than optimal soil conservation. Use of taxes, subsidies, and/or regulations can bring about more nearly efficient allocations to conserve soil by aligning social benefits with social costs. Of course, such interventions are inappropriate if they entail larger social costs than the market failure they were designed to correct.

—In a similar vein, social benefits are sometimes less than private benefits. Application of pesticides significantly benefits producers and consumers in many instances. In other instances, residues from pesticides or growth-stimulating hormones in food may provide health hazards to consumers—benefits to consumers not only are less than to producers but are negative. It is important for the public sector to monitor the food chain for residues harmful or potentially harmful to health because the market alone will not assure safety.

—Soil conservation practices and structures providing discounted future benefits in excess of discounted costs are economically desirable. Pressed by the economic vicissitudes of the here and now including intense pressures to meet current cash-flow requirements of family living and mortgage expenses, many producers have neither time nor money to follow appropriate soil conservation measures. Pressures for immediate consumption raise the private discount rate to high levels relative to the social rate. The latter, based on the real interest rate, has averaged 2-3% for some decades prior to the 1980s and reflects a small premium indeed placed by the public on present versus future consumption. Some public intervention is justified in private markets to help reduce private discount rates to the level of social discount rates and hence place greater premiums on preserving agricultural resources for the future.

—An efficient agriculture must see to provision of public goods.[2] Agricultural research and extension have many properties of a public good; once technology is developed the cost is zero for the technology per se to be made available to all, hence the technology is not rival. Under such conditions real national income is reduced if users must pay a price to obtain the tech-

[2] Public goods in pure form are neither rival nor exclusionary and hence are not well suited for allocation by markets alone. A nonexclusionary good such as open-pollinated seed cannot easily be withheld from all farmers if made available to one farmer. Because a private company which develops the seed will be unable to appropriate the benefits in the form of enough receipts to cover development costs, it will not develop the variety. Public goods that are nonrival may or may not be exclusionary. Goods which are exclusionary can be withheld from others after being purchased by someone. Hence the free rider problem is alleviated and the private firm finds it profitable to engage in research advancing new technology.

In the case of a nonrival good, consumption by one firm or individual does not reduce consumption by others. It does not make economic sense to charge for and restrict use of nonrival goods because to do so reduces net benefits of progress to society. There is merit in having publicly funded institutions to research and disseminate public goods.

nology. But tax-supported agricultural research and technology development is often underfunded. Consequently, low-cost sources of future output are foregone. Patent rights give monopoly pricing power and make agricultural technology and appropriable, attractive investment for private firms. Some users who could benefit in excess of cost from the technology are denied access because of the user charge. The greater incentive provided by the user charge speeds development of new technology. The nonrival nature of the technology calling for release at no marginal cost is lost when the research is done by private firms with patent protection but the benefits of more output of technology from greater incentives may more than compensate society. A mixed private-public sector has merit. Public institutions can contribute most to society by emphasizing basic research least attractive to private development. Such research offers very high social if not private returns relative to costs.

In short, an economically, socially, and environmentally viable food and agriculture system allocates resources where discounted social (as opposed to private) returns are greatest relative to discounted social costs, provides for those who do not have the means to provide for themselves, respects the desires of an informed public to preserve and foster amenities and institutions such as the family farm and reverence for the land, and acknowledges the importance of meeting food and fiber needs of current and future generations.

The next three sections of this report deal with economic, social, and environmental viability. The section on economic viability will examine the ability of farmers to cover all costs and maintain or even increase output over the long run. This ability depends on supply-demand balance, comparative advantage, commodity programs, and technology. The section on environmental and natural resource viability especially examines the capacity of agriculture to maintain natural resources and healthful food supplies in the face of urban encroachment, soil erosion, mining and contamination of groundwater, and increased application of chemicals. The section on social viability analyzes the vitality of the family farm, and, indirectly, its capacity for sustaining its unique moral and social contributions to local communities and to society.

The three realms entail conflicts and trade-offs. For example, measures to preserve the family farm and small rural communities can raise production costs, thereby interfering with ability of agriculture to cover costs at world market prices. Excessive use of nonrenewable water supplies, subsidies for irrigation water which in turn builds up salts in soils, or overuse of chemicals may reduce short-term costs to farmers but erode agriculture's long-term capacity to fulfill social and economic objectives. The market alone will not address the social and environmental issues; the appropriate trade-offs must be made by the public through the political process—an issue addressed in the final section. Public decisions are informed by economic analysis estimating benefits relative to costs of pursuing social objectives. It is clear that economic, social, and environmental issues cannot be neatly separated.

4. Economic Viability

The heady optimism for persistently rising farm commodity prices in the 1970s gave way to despair in the 1980s. The optimism and despair closely correlated with agricultural exports, which, if favorable, raise commodity demand and farm prices. With falling exports and financial stress in the 1980s, it is being said by some that U.S. agriculture has lost its comparative advantage; that is, its ability to compete with other nations for world export markets.

The pace of technological change as apparent in productivity gains among nations plays a key role in comparative advantage, the future balance of agricultural supply and demand, and real farm prices and income—hence in the economic viabilty of American agriculture. This section begins with a discussion of past and prospective technological change, productivity trends, and comparative advantage. It concludes with implications of supply and demand trends for future economic viability of food and agriculture.

The message of this section is (1) the basic human and material resource endowment, infrastructure, and technological progress which gave the U.S. a comparative advantage in farm products in past decades have not altered fundamentally in the 1980s but have been masked by transitory phenomena such as recession and financial crisis abroad, an overvalued U.S. dollar, and unduly high price supports in the Agricultural and Food Act of 1981; and (2) anticipated future trends provide a basis neither for despair nor rosy optimism. The average balance between aggregate supply and demand is likely to be narrow; no *sharp* upward or downward secular trend in real food prices is anticipated. There will be substantial deviations around that trend; the principal economic problem of agriculture will continue to be annual and cyclical price and income instability. American agriculture and adequate-size, well-managed family farms not only will survive but will continue to exhibit economic vitality. However, public policy must be supportive in addressing technological, economic, social, and environmental concerns.

Comparative Advantage

A nation is said to have a comparative advantage in those industries and commodities in which it makes the greatest profit (highest returns per unit of resources fixed to the country such as land and labor) in a well-functioning world trade market.[3] Public macroeconomic, commodity, and trade policies and other forces such as weather cycles often mask long-term comparative advantage. For example, when U.S. foreign exchange was temporarily overvalued in the first half of the 1980s, the commodity exported at "least loss" (when all costs are considered) had the comparative advantage. Returns to fixed resources are maximized by exporting even if export prices cover only *variable* production costs. Failure of U.S. farm exports to cover the full cost of production in recent years indicates neither that it is irrational to export nor that the nation has lost its comparative advantage.

Studies cited in this section make a strong case not only for current but future U.S. comparative advantage in agricultural products, especially wheat, coarse grains, and soybeans—the major world agricultural exports. The U.S. does not have and is unlikely to have a comparative advantage in production of sugar and some dairy products for nonfluid uses. Meat and poultry products for the most part will be nontraded goods—neither imports nor exports will dominate markets. It should be kept in mind that for the U.S. to realize the substantial economic gains from comparative advantage through freer trade in grains and soybeans and in nonfarm goods and services, it may have to sacrifice economic protection of other commodities.

Comparative advantage reveals itself when markets are open at home and abroad. Several studies of impacts of trade liberalization provide insights into comparative advantage. Parikh et al. (1986, Table 5.4) estimate that free trade would reduce agricultural acreage and export value in Japan and the European Community but acreage would rise by as much as 2.5% in the United States, 2.4% in Canada, and 4.3% in Australia. The volume of U.S. wheat exports would increase up to 19% and of feed grains up to 12% from liberalization, but the country would become a major importer of sugar and dairy products.

Research indicates that if the U.S. alone were to drop its international trade restrictions, agricultural commodity prices worldwide would be altered. According to analysis by Tyers and Anderson (reported by the World Bank, 1986), the international price of wheat would rise 1%, coarse grain prices would fall by 3%, and there would be a 5% increase in the price of dairy products. If *all* market economies liberalized trade, even more significant changes would occur. The

[3] Full social costs and returns including externalities from environmental degradation must be included to measure true comparative advantage in the long run.

international price of wheat would go up 9% and the price of coarse grains would grow by 4%. Beef and lamb prices would rise 16% while prices of dairy products would show a 67% increase. U.S. grain prices adhere closely to world prices, so producers would realize some economic benefits.

More important are opportunities for greater quantities of exports. If all market economies liberalized agricultural trade, Tyers and Anderson estimate that world trade volume in wheat would rise by 6%, in coarse grains by 30%, in rice by 97%, in sugar by 60%, and in poultry and livestock (including products) by 190 to 295% (Table 4.1). The United States would benefit from higher prices and quantities for grain. Overall world efficiency gains from liberalized trade were estimated to be $41 billion (World Bank, 1986, p. 131).

Economic viability of agriculture is impaired by instability. Another dividend from liberalized trade is markedly reduced world price instability. For example, Tyers and Anderson (World Bank, 1986, p. 131) estimate that the coefficient of variation (standard deviation dividend by mean) in world wheat prices would decline from .45 without stabilization to .10 with stabilization; coarse grains would fall from .19 to .08; beef and lamb from .09 to .04; pork and poultry from .09 to .04; and dairy products from .16 to .04.

Results from four econometric models of world trade reported by Meilke (1987) provide further insight into comparative advantage. With more open world trade, the U.S. wheat price was projected to be as much as 44% higher. Gains in U.S. wheat exports come largely from reduced European Community exports, predicted to drop as much as 16 million metric tons. The U.S. price for coarse grains could be as much as 19% higher from open trade.

Given past imports, it is surprising to note that the U.S. appears to have a comparative advantage in beef. That advantage has been concealed by international policy distortions. Sanderson (1986, pp. 21-23) notes studies showing that with trade liberalization U.S. beef producers would realize an estimated 13% price increase and the nation would become a net exporter. On the other hand, the studies indicate that U.S. dairy and sugar producers would face an estimated 36% and 25% price cut, respectively.

Vollrath (1987) measured *revealed comparative advantage* (RCA) from trends in exports and imports for individual countries relative to the world. RCA coefficients are influenced by resource endowments, technology, and income, but also are influenced by government policies which distort real comparative advantage. According to his analysis, Australia and especially Argentina have a comparative advantage in wheat production relative to the United States (Table 4.2). Excellent soil and climate combine with low labor costs to make Argentina highly competitive. But Australia and Argentina are unlikely to be decisive competitors. Argentina's resources for wheat compete with those used to produce corn, soybeans, and cattle. Australia and Argentina combined account for a small share of world wheat exports. Canada has a small comparative advantage over the U.S., but has unstable production and is frequently troubled by delivery problems. Parts of France are highly competitive and the comparative advantage of France is

Table 4.1. International price and trade effects of liberalization of selected commodity markets, 1985 (World Bank, 1986, p. 129)

Country or country group in which liberalization takes place	Wheat	Coarse grains	Rice	Beef and lamb	Pork and poultry	Dairy products	Sugar
Percentage change in international price level following liberalization							
European community	1	3	1	10	2	12	3
Japan	0	0	4	4	1	3	1
United States	1	-3	0	0	-1	5	1
OECD[a]	2	1	5	16	2	27	5
Developing countries	7	3	-12	0	-4	36	3
All market economies	9	4	-8	16	-2	67	8
Percentage change in world trade volume following liberalization							
European community	0	4	0	107	3	34	-5
Japan	0	3	30	57	-8	28	1
United States	0	14	-2	14	7	50	3
OEDC	-1	19	32	195	18	95	2
Developing countries	7	12	75	68	260	330	60
All market economies	6	30	97	235	295	190	60

[a]Organization of Economic Cooperation and Development.

Table 4.2. Trends for top five exporters and for top 20 importers of wheat and wheat flour (based on 1980-84 average), and comparative advantage (Vollrath, 1987)

Country	1,000 mt[a], wheat equivalent					Comparative advantage
	1961-65	1966-70	1971-75	1976-80	1980-84	relative to United States
Exporters						
United States	20,002	1,799	27,266	31,955	41,639	---
Canada	11,813	10,939	12,741	14,466	19,466	Higher and constant
France	3,008	4,717	7,260	6,008	13,974	Lower and rising
Australia	6,072	6,453	7,466	9,814	11,113	Higher and rising
Argentina	3,243	2,891	1,925	3,981	5,960	Higher and rising
Importers						
USSR	71	2,477	2,317	7,494	19,172	Lower and falling
China	4,570	4,840	4,501	7,251	11,885	Much lower
Egypt	1,755	1,983	2,630	4,721	6,060	Much lower
Japan	3,108	4,152	5,250	5,658	5,536	Much lower
Brazil	2,157	2,381	2,206	3,762	4,478	Much lower and rising
Poland	1,705	1,256	1,604	2,697	3,026	Much lower
Algeria	361	594	1,192	2,251	2,901	Much lower and falling
Iraq	150	99	443	1,302	2,427	Much lower and falling
Iran	247	100	1,096	815	2,181	Much lower and falling
South Korea	526	989	1,703	1,822	2,065	Much lower and rising
Morocco	289	544	885	1,446	1,967	Much lower and falling
Italy	736	653	1,270	2,191	1,937	Much lower and constant
India	4,529	5,344	3,095	1,347	1,788	Lower and rising
Indonesia	101	337	647	955	1,519	Much lower and rising
Bangladesh	459	790	1,679	1,108	1,519	Much lower and falling
Nigeria	68	174	374	1,004	1,371	Much lower and falling
Chile	257	352	638	830	1,001	Much lower and falling
Peru	411	564	622	740	876	Much lower and constant
Venezuela	424	679	619	746	859	Much lower and constant
Philippines	414	556	592	722	829	Much lower and constant

[a]Metric tons.

growing. But wheat exports could be restrained by resistance of EC taxpayers to huge subsidies paid for exporting. French farmers could compete in world markets without subsidies but they may prefer to receive subsidies and export less.

Trends in the top 20 importers of wheat appear to be favorable to exporters (Table 4.2). India and possibly China may become competitors, but pressures to upgrade diets of their own populations and to diversify will constrain their exports. Many nations seek self-sufficiency but this goal is not new.

Vollrath (1987, p. v) concluded that the U.S. wheat subsector is more competitive in international markets than in U.S. agriculture as a whole. And the U.S. comparative advantage in coarse grains and oilseeds appears to be even greater than in wheat. Some areas of Argentina and Brazil can produce soybeans at lower cost per unit than the United States but many South American areas produce soybeans at high cost. As noted in Table 4.3, Argentina produces corn cheaply. One reason is because it uses little fertilizer. Producers follow several years of crops with several years of pasture to maintain fertility. Low-input Argentine production falls well short of supplying the world export market.

The Agricultural Policy Working Group (1987, p.6), a consortium of agriculturally related businesses, concluded that the decline in U.S. agricultural competitiveness in the 1980s was the result of harmful macroeconomic and commodity program policies rather than a loss of basic comparative advantage. The study concluded that U.S. agriculture's comparative advantage probably has grown due to more rapid productivity growth in U.S. agriculture relative to agriculture in the rest of the world and relative to other economic sectors in the U.S. The study noted that U.S. farmers are in a more favorable position to expand production at lower cost than farmers elsewhere because of idle capacity in the farm and agribusiness sectors.

Table 4.3. Variable costs of production (Westbrook, 1987, p. 26. Numbers in parentheses for soybeans are from Mangold, 1987, p. 17)

Country	Corn ($/mt[a])	Wheat ($/mt)	Soybeans ($/mt)	
United States				
Cornbelt	55.34	54.02	69.35	
Overall	58.70	68.27	88.36	(69.73)
Argentina	45.60	42.26	79.80	(67.82)
South Africa	61.12	---	---	
Thailand	43.98	---	---	
Brazil	73.28	---	117.35	(88.84)
France	91.52	48.36	---	
Australia	---	42.45	---	
United Kingdom	---	66.62	---	
Canada	---	57.66	---	

[a]Dollars per metric ton.

If prices were extremely low, the United States could change production practices to reduce variable costs but perhaps not to the low levels in Argentina because U.S. labor costs are higher. A number of U.S. farmers and agencies are experimenting with low inputs, diversified enterprises, and soil-conserving production practices designed to reduce costs while maintaining or raising profits. Such procedures (which have similarities to the Argentine model) are being evaluated and are mentioned later under the subheading "Technology Advances for Soil Conservation."

The U.S. Office of Technology Assessment (1986a, p. 6), after examining numerous crop budgets for the United States and its competitors, concluded "that a large percentage of U.S. farms are competitive with the most efficient producing areas in the world. On the other hand, it appears that some U.S. farmers are operating at costs above world prices." The OTA report (1986a, p. 11) also noted the unavoidable tension between the objective of domestic equity—maintaining the profitability of domestic farmers in different production cost categories—and the goal of creating a farming industry that can compete successfully in an international market free of foreign export subsidies.

Commodity budgets, although often relied upon to judge comparative advantage, present a fragmented picture. Based on evidence compiled from various sources, the comparative advantage for U.S. grains and soybeans if graphically summarized in Figure 4.1. The U.S. export supply curve is S_{US} and competing exporters' supply curve is S_O. World commodity supply p_oaS_T is the horizontal sum of S_O and S_{US}. Below price p_O, exports are zero. Argentina would begin exports at P_O to be joined first by Australia, then Canada, and then France in the case of wheat. The United States begins to export when price reaches p_1. With the world's largest mass of favorable soil and climate combined with the strongest supporting infrastructure of transportation, research, extension, and marketing facilities, the comparative advantage of the United States coupled with its capital intensity becomes apparent when the United States supplies more than all competitors combined above price p_2. It is apparent from Figure 1 that the United States will have a small share of the market if demand intersects total supply S_T below p_1 but will have the largest share of the world export market if demand intersects supply at equilibrium above price p_2. This pattern of comparative advantage characterized by a heavily capitalized agriculture in a highly developed U.S. economy will give the appearance of the nation

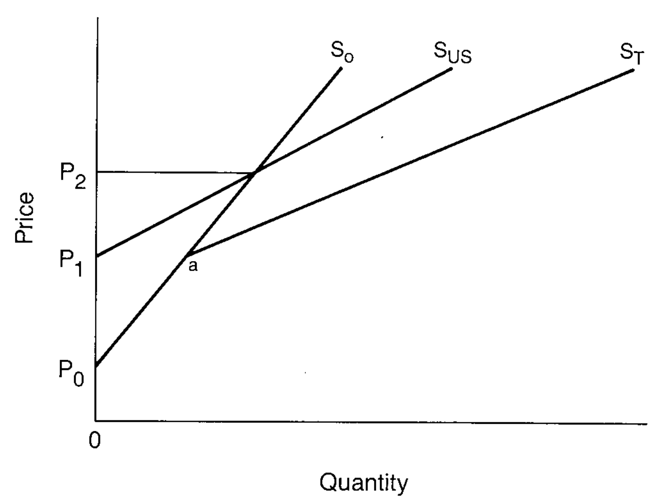

Figure 4.1. Export supply curves for U.S. (S_{US}), other exporters (S_O), and total (p_oaS_T).

being a residual supplier. Such a role will be rational, however, and emphasizes the importance to the United States of keeping world trade channels open so that demand intersects S_T at high levels.

Supply

Future economic vitality of agriculture will depend not just on current comparative advantage but on trends in supply and demand. It is well to review briefly projections of such trends, first in supply and then in demand.

Supply increases from productivity gains. Yield trends measure productivity gains for individual commodities and aggregate U.S. productivity trends measure the big picture. If one enterprise becomes more or less productive and profitable than another, producers shift resources until returns are similar among enterprises. Thus knowledge of trends in composite productivity and aggregate supply help to predict future economic vitality of U.S. agriculture.

Yields

The recent comprehensive study by the U.S. Office of Technology Assessment (1986b) is pessimistic about yield trends to year 2000. Table 4.4 shows past and projected crop yields, the latter from OTA for the 1982-2000 period. Given current publicity anticipating accelerated productivity with the new biotechnology, it is notable that the OTA projections depict a sharply slower yield growth rate for 1982-2000 than the actual rate of increase in yield per acre for 1950-1985. An exception is soybeans for which past and projected rates are comparable. The major impact of the new biotechnology may not be felt by grains until after year 2000, but the pace of yield increments anticipated by OTA in Table 4.4 seems to be unduly slow.

However, Johnson and Wittwer (1984, p. 46) also anticipate a very low rate of yield increase in relation to past rates, projecting that overall U.S. crop yields will rise only 1.07% annually from 1980 to 2030. The U.S. Department of Agriculture (1986b) projected average annual yield increases of only 1.2 to 1.5% for corn and 1.2% for wheat for 1982 to 2030, rates well below the 1950 to 1985 trend shown in Table 4.4.

OTA also projected productivity growth for livestock from 1982 to 2000. Measured by output per unit of feed or per animal unit, livestock productivity was projected to expand slowly—even more slowly than for crops. A notable exception to these trends was dairy. Pounds of milk per pound of feed was projected to increase only 0.2% annually for the 1982 to 2000 period but milk per cow was projected to increase an average of 3.9% annually. Bovine growth hormone and other products of biotechnology were projected to double milk per cow. Given the slow increase in milk demand, cow numbers were expected to fall sharply. Except for dairy, the foregoing projections hardly anticipate a high-technology revolution before year 2000.

The yield projections from OTA and from Johnson and Wittwer raise the issue of whether yields are plateauing. Figures 4.2 to 4.5 help to resolve that issue (Tweeten, 1987). Many functional forms of regression equations were tried but the best fit to annual U.S. data for 1950-85 was achieved with the double logarithm form.[4] The most notable conclusion from

[4] ln yield per planted acre = ln a + b ln T where ln is natural logarithm and time trend T was the last two digits of the current year. Several other origins for T were used but with less favorable results. Other functional forms were fitted to the data with less satisfactory results in terms of coefficient significance and R^2. The only equation improving results was the wheat equation ln yield/planted acre = 2.617 - .264 ln harvested wheat acreage + 1.629 ln T (T = 50 . . . 85). All coefficients were significant at the .01 level; the R^2 was .89; the predicted percentage rate of increase in yield was 3.26 in 1950 and 1.92 in 1985; and the predicted absolute bushel/yield increase was .47 in 1950 and .65 in 1985. These yield estimates provide inferences comparable to those in the text.

Table 4.4. Crop yields and yield increases per harvested acre, actual 1950-1985 and projected 1982-2000 (U.S. Office of Technology Assessment, 1986b and other sources)

	Actual			Projected (OTA[a])	
Crop-unit	1950	1985	Annual increase (%)	2000	Annual increase (%)
Corn - bu/A[b]	38.2	118.0	3.27	139	1.2
Upland Cotton - lb/A[c]	269.0	628.0	2.45	554	0.7
Soybeans - bu/A	21.7	34.1	1.30	37	1.2
Wheat - bu/A	16.5	37.5	2.37	45	1.3

[a]U.S. Office of Technology Assessment.
[b]Bushels per acre.
[c]Pounds per acre.

Figures 4.2 to 4.5 is that yield per planted acre of major crops and overall farm productivity increased in nearly a straight line from 1950 to 1985.

In all cases except wheat, yield variability was larger in recent years than in earlier years. The graphs provide no evidence that excess capacity and financial stress in the 1980s are the result of a sudden surge of productivity apparent in higher crop yields (Figures 4.2 to 4.4) or overall output-input ratios (Figure 4.5).

Yield plateauing may be *weak form* (percentage rate of increase in yield declining over time but absolute yields increasing) or *strong form* (absolute increments as well as percentage increments in yield declining over time).[5] In every case—for corn, soybeans, wheat, and overall farm output per unit of production resources (productivity) shown in Table 4.5—weak-form plateauing was apparent.

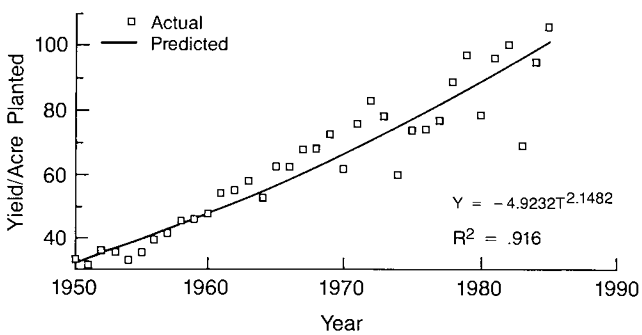

Figure 4.2. Actual and predicted yield per planted acre of corn, U.S. (Tweeten, 1987).

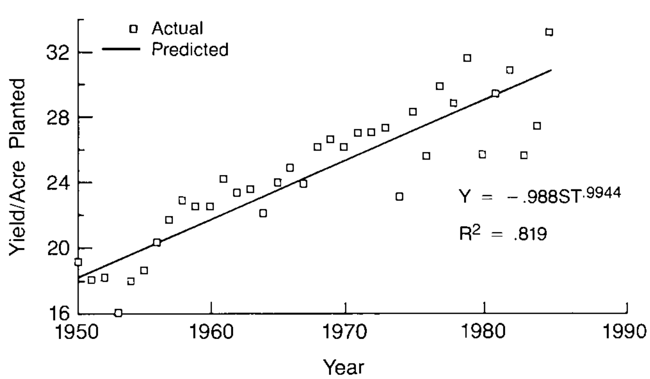

Figure 4.3. Actual and predicted yield per planted acre of soybeans, U.S. (Tweeten, 1987).

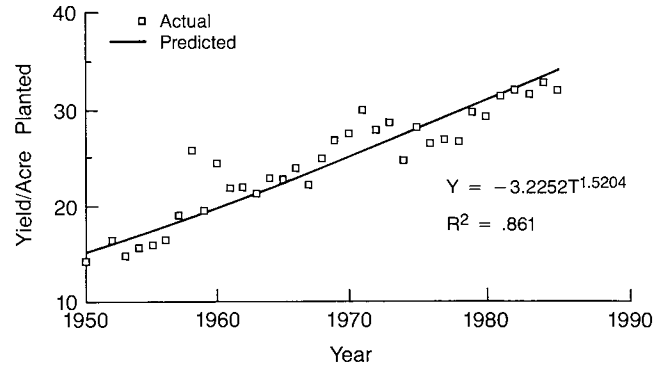

Figure 4.4. Actual and predicted yield per planted acre of wheat, U.S. (Tweeten, 1987).

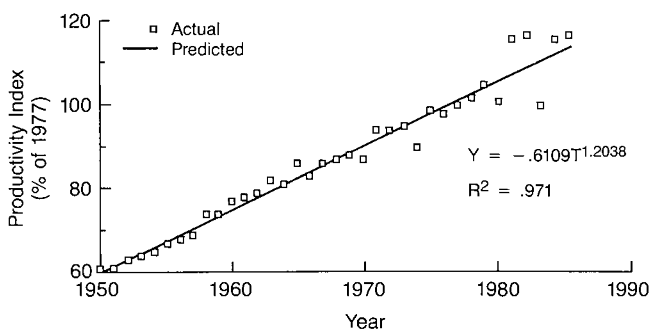

Figure 4.5. Actual and predicted productivity index (output per unit of all production inputs) for U.S. agriculture (Tweeten, 1987).

The 1950 and 1985 values are points on a trend which is continuous between these years. Some evidence of strong-form plateauing was apparent only for soybeans. In every case the *rate* of increase slowed but the annual absolute increments grew except for soybeans based on predictions from regression equations used to construct Figures 4.2 to 4.5.

[5] Plateauing in the strongest form of no absolute increase in yields was not apparent in any case.

Acreage was included in all equations as an independent variable but did not significantly influence yields except for wheat as noted in the previous footnote. Thus plateauing cannot be attributed to increased planting on inferior acres.

Table 4.5. Farm output per unit of production resources (productivity) for corn, soybeans, and wheat (Tweeten, 1987)

	Absolute annual increase		Annual rate of increase (%)	
	1950	1985	1950	1985
Corn				
Bu/planted acre	1.40	2.57	4.30	2.53
Bu/harvested acre	1.60	2.88	4.21	2.48
Soybeans				
Bu/planted acre	.36	.36	1.99	1.17
Bu/harvested acre	.32	.29	1.62	0.95
Wheat				
Bu/planted acre	.46	.61	3.04	1.79
Bu/harvested acre	.52	.68	2.99	1.76
Total productivity (1977 = 0)	1.45	1.62	2.41	1.42

In short, past yield trends give evidence of weak-form plateauing (rates of increase are slowing) but not of strong-form plateauing. Successive technological revolutions bring ever higher rates of productivity growth but the growth rate slows as a revolution matures (Tweeten, 1987). The United States is between revolutions, a difficult time for prediction, and of interest is whether the next decades will be characterized by diminishing productivity rates of the past revolution or by accelerating rates of the incipient revolution featuring the new biotechnology and information system.

Alternative Projections

Future increases in yields and productivity influencing viability of agriculture depend partly on investment in agriculture science. Table 4.6 shows productivity projections to year 2025 under alternative investment rates in a high-technology environment. Variables are defined in the footnote to the table.

Growth in productivity (PIND) of farm production resources is a function of public real investment in agricultural production-oriented research and extension (POPR). The average productivity growth rate ranges from 1.99% per year from 1982 to 2000 (with POPR increasing 3% per year) to 2.25% per year (with POPR increasing 7% per year). The 3% POPR growth rate is near historic levels; if that rate is continued in the future then the slower growth in productivity and supply is most likely.

Real farm price PR falls in most scenarios but increases slightly if demand for farm output grows 2% per year and POPR grows 3% per year. Gross farm income is not influenced much by POPR because lower prices offset output growth from more rapid rates of increase in POPR. Like other variables, net farm income NFI is in real terms and is maintained reasonably well beyond year 2000 if POPR increases 3% per

Table 4.6. Annual growth rates of selected aggregate farm variables under alternative growth rates in agricultural research and extension outlays for the period 1982-2025 (Braha and Tweeten, 1986, p.17)

Annual growth in POPR[a]	PR[b]	Qs[c]	GFR[d]	NFI[e]	PIND[f]
			%/year		
Shift in Demand = 1.5%					
3%	-0.30	1.86	1.56	-0.90	1.99
5%	-0.37	1.93	1.55	-2.61	2.12
7%	-0.44	1.99	1.55	-9.00	2.24
Shift in Demand = 2.0%					
3%	0.03	2.07	2.04	1.89	1.99
5%	-0.12	2.14	2.03	1.50	2.12
7%	-0.18	2.21	2.03	0.90	2.24

[a]POPR: Production-oriented public research and extension real outlays for agriculture, alternatively assumed to grow at rates of 3, 5, and 7 % per year.
[b]PR: Ratio of index of prices received to prices paid by farmers.
[c]Qs: Quantity supplied of farm output.
[d]GFR: Gross farm income.
[e]NFI: Net farm income.
[f]PIND: U.S. Department of Agriculture's index of productivity, or aggregate output of crops and livestock per unit of production input.

year and demand increases 1.5% per year. High rates of increase in demand allow a larger increase in POPR without reducing net farm income. The internal rate of return, the highest interest rate that could be paid on POPR outlays and just break even on the investment, was estimated to be 45% in 1982 and remains well above returns on alternative investments unless high rates of increase in POPR are associated with a low rate of increase in demand.

Farm economic conditions are highly sensitive to trends in demand and supply. If demand grows faster than 1.5% per year, faster rates of growth in POPR than the historic rate of 3% per year are desirable to obtain productivity gains which benefit consumers and others. However, high rates of productivity growth coupled with slow demand growth either would markedly reduce farm net income or would require major income support to farmers from government.

Some of the pessimism regarding future production potential of agriculture could come from ground water depletion for irrigation. Current irrigation levels with average precipitation result in "mining of over 22 million acre feet of water from aquifers west of the Missouri-Mississippi Rivers" (Council of Economic Advisors, 1987, p. 151). Nationally, almost one-fourth of groundwater used by agriculture is not replenished. About one-quarter of the irrigated land in the West depends heavily on nonrenewable water supplies, and the productivity of the several million additional acres is threatened by rising salt levels (Council of Economic Advisors, 1987, p. 151).

Despite these misgivings, the Council of Economic Advisors (1987, p. 162) noted that the emerging revolution in biotechnology along with "more efficient use of resources, more effective management, and regional shifts in production patterns could, under the right circumstances, expand the production of agricultural products within the United States (and lead) to a 2.4 percent productivity growth rate forecast for U.S. agriculture as a whole." Tutwiler and Rossmiller (1987, p. 22) propose that "the probability is high that the rate of productivity growth in the United States will be 2.4 percent annually." The conceptual and empirical foundation for the latter two estimates of 2.4% growth was not documented by the authors. The estimates deviate sharply from past trends in productivity, are higher than those from more analytical projections, and are of unknown validity but provide an upper boundary to the expanded range of future productivity advances.

Demand

Aggregate domestic demand trends can be predicted with some precision. With domestic population increasing approximately 0.9% annually, per capita real income increasing 2% per year and each 1% increase in real income resulting in a 0.1% increase in demand for farm output (income elasticity of demand), it follows that domestic demand will increase approximately $0.9 + 0.1(2) = 1.1\%$ per year for the next decade. Population and domestic demand growth are expected to slow gradually, and probably will be well below the above rates by year 2000 and beyond.

In contrast to domestic demand, export demand cannot be predicted with much reliability. After a detailed analysis of world supply-demand trends, O'Brien (1984, p. 51) concluded that "growth in U.S. exports should expand 3 to 4 percent per year from 1985 through 1990." He (1984, p. 51) also noted that "Foreign demand is fast becoming the only significant source of growth in demand for the burgeoning supplies of farm products likely to be available in the United States over the next several years." Per capita domestic consumption of many farm products is approaching saturation levels and is not significantly influenced by the state of the domestic economy. Export demand growing at nearly triple the rate of growth in domestic demand will increase U.S. reliance on world markets. The rest of the world will become more dependent on a few exporters, particularly the United States.

Sanderson (1984, p. 63) reviewed the projections of O'Brien and reported on a joint Resources for the Future/Economic Perspectives, Inc. study which forecast "no reversal of the long-term downward trend in real food prices." More recent studies tend to concur with that forecast. Sanderson (1986, p. 17) projected that the total volume of U.S. agricultural exports will increase 3.1% per year from 1983 to 2000. For the period from 1979-81 to year 2000 (a period with a higher base and hence with slightly slower annual growth than the 1983-2000 period above), annual grain exports were projected to increase 2.2% per year, oilseeds by 2.4% per year, and cotton by 1.8% per year. This contrasts starkly with respective annual export growth of 11%, 7%, and 11% in the 1970s for grain, oilseeds, and cotton, respectively.

We now combine the domestic and export projections to estimate the growth rate in total demand for farm exports to grow 3% per year. Combining this with domestic demand growth of 1.1% per year and recognizing that 20% of output currently is exported, the projected rate of growth in *total* demand for output is 1.5% annually to year 2000.[6]

As noted earlier, predictions of export demand are crude at best. Based on views of some Task Force experts the rate of increase could be double that assumed—still well under the 10% export growth rate of the 1970s. The export projection is more likely to be realized if the United States pursues foreign assistance policies such as discussed later to increase effective demand in developing countries. If exports grow 6% per year and domestic demand grows 1.1% per year, total demand will grow an average of 2.4% per year to year 2000.

Supply-Demand Balance

Real food prices rise if demand grows faster than supply and fall if demand grows slower than supply. It is of interest that the low estimates (1.5%) of supply and demand trends match as do the high estimates (2.4%), implying no real change in food prices. Of course, an infinite number of supply/demand trend combinations are possible. Based on the historic productivity trend in Figure 4.5, supply was growing 1.4% in 1985 and the growth rate was falling. Using this projection, demand growth at either the 1.5 or 2.4% per year rate projected earlier points to rising real food costs, increasing pressure on farmland resources, and rising real farm income after current excess capacity is absorbed.

Numerous studies have predicted pressures on America's cropland base by year 2000. The final report of the National Agricultural Lands Study (1981, p. 56) listed "mid-range" projected rates of growth in total demand for farm output of 3.1% per year from 1985 to 1989, 2.6% from 1990 to 1994, and 2.25% from 1995 to 2000. Productivity advances were not expected to keep pace, hence they concluded that "By the year 2000, most if not all of the nation's 540 million acre cropland base is likely to be in cultivation" (p. 1).

William Larson (1984, p. 73) echoed that conclusion, stating: "After a long period of decline in the amount of cropland used for production, cropland acreage no doubt will increase during the remainder of this century until all, or nearly all, of our cropland base is in production." Earlier estimates of productivity trends from Johnson and Wittwer and the Office of Technology Assessment also support this scenario of rising real food prices, increasing pressure on cropland, and rising real farm income. In contrast, Crosson (1982) concluded that supply likely can be expanded enough to accommodate projected demand, but Heady (1982) cautioned: "There are grounds for optimism that this can be done, but no room for complacency." Rapid supply growth of 2.4% per year projected by the Council of Economic Advisors and by Tutwiler and Rossmiller cited earlier, coupled with slow demand growth of 1.5% per year would sharply depress farm and food prices. Aggregate agricultural resource volume would need to fall substantially. Pressure on the farm economy would be intense as would be calls for government intervention to raise farm income.

These higher projections of productivity gains appeared to be guesstimates based on early gains from biotechnology. A more realistic estimate is from Table 4.6 which projects supply to grow just under 2% per year if historic trends in investment in agricultural science and technology continue. This Task Force predicts a turnaround in productivity and supply growth in the historic trend. If exports grow 4% per year and domestic demand grows 1.1% per year, then projected supply growth (1.99% per year) exceeds the projected demand growth (1.79% per year) by 0.2 percentage points per year, which implies that real farm prices will fall on average by approximately 1% annually based on conventional estimates of the aggregate price elasticity of demand. This projection of a modest real price decline is broadly in line with other studies including the most realistic scenario in Table 4.6. Real net income per commercial farm can be maintained or increased, however, by lower costs made possible by productivity gains and outmigration of youth from farming at rates no higher than those in the past three decades. Less cropland would be needed in the future. The farming industry would be economically viable without government price and income support intervention in such a scenario—if current excess capacity were alleviated through a Conservation Reserve Program or other means.

Changes in Composition, Quality, and Variety of Food

Emphasis thus far has been on aggregate quantity of farm and food products. Composition, quality, and variety are also important. Changes in life styles and diet and health issues affect these dimensions of

[6] The growth rate speeds up with time as faster growing exports become a larger proportion of demand. However, slower domestic population growth will partly offset the greater weight of exports.

products in the rapidly changing consumer environment. The total quantity of food consumed per capita in the United States may not change much unless the recommended dietary allowances (RDAs) are taken seriously. If consumers followed the recommended guidelines, there would be a 10 to 15% reduction in overall food consumption in the United States. Roe (1986) in the *Yearbook of Agriculture* cites obesity as one of the serious health problems in the United States. This can be corrected by reducing caloric intake, increasing energy output, or combining both. Caloric intake has been on the decline since the early 1900s. Lemaire (1985) stated that daily caloric intake has dropped from about 3,500 calories to between 3,300 and 3,400 and is projected to decline to 3,000 calories per capita by the year 2000.

Producers and consumers are affected not only by the reduction in total caloric intake but also by the shift in consumption from sugar to corn sweeteners, from beef to pork and poultry, from potatoes to other vegetables, and to an overall reduction in egg, butter, ice cream, and whole milk consumption. Trends in meat consumption are discussed elsewhere (see Farrell, 1978, pp. 247, 248). These are major shifts in food consumption relating to the diet and health of consumers. The changes create instability and adjustment problems to producers but do not threaten the long-term viability of U.S. agriculture.

Quality of Food

Because it appears there will be sufficient supplies of food, the competitive position of U.S. farm products and processed foods may be determined increasingly by quality in the future. Quality of food may be defined as the composite of those characteristics differentiating individual units of a product and having significance to the buyer in determining the degree of acceptability of that unit (Kramer and Twigg, 1970). Quality is a degree of excellence related to such sensory attributes as appearance, flavor, and color which are easily determined and such hidden attributes as yield, nutritive value, and safety which are not so easily determined by the consumer.

What is the overall quality of the food supply? Many people perceive that the U.S. diet is deteriorating as a result of junk foods, overprocessing, poor nutritional content, use of food additives, and food safety problems. Paarlberg (1980) indicates this concern is overblown: hard evidence includes reductions in nutrition-related diseases as rickets, goiter, scurvy, and beri beri; the height of children is exceeding their parents'; and the life span has increased. He states that the greatest nutritional problem is obesity which is heavily influenced by individual consumer's tastes, preferences, genetic makeup, and by culture.[7] Developing sound information regarding what constitutes a healthful diet and educating people accordingly is a continuing public health concern.

Along with attention to overall quality of raw agricultural products and processed food as perceived by the domestic consumer, U.S. agriculturalists are also concerned with the overall quality of U.S. farm and food products as they enter into international trade channels. Can U.S. exports compete in quality with those from other countries at the point of use? Numerous news accounts relate that some corn, wheat, and other agricultural products are virtually unusable on arrival in distant ports. Is this a problem of initial quality of agricultural products; problems in grading, storing, and transportation; or a combination of sources? For the U.S. consumer or the export buyer to obtain quality agricultural or processed food products, it is necessary for all partners in the food system to understand and consider what is required at every phase of the operation. New technology becoming available will affect the quality of raw agricultural products and of processed foods. New biotechnological techniques will make possible the development or design of domestic plants and animals more closely suited to the dietary needs and tastes of consumers (Knorr and Sinskey, 1981). This could include increased nutritional protein content in grains, lower fat content in meats, higher vitamin content in fruits and vegetables, and lower levels of natural toxicants in selected agricultural products.

Changes in the present grades, standards, and payment plans for agricultural products are needed to encourage production of more nutritionally desirable products. Payment for milk on a protein/total milk solids basis rather than on a fat basis and adjustment in meat yield grades to encourage production of lower-

[7] Roe (1986) and Pariza et al. (1986) relate the importance of diet to such chronic diseases as heart disease, hypertension, kidney disease, cancer, diabetes, and osteoporosis. In addition, many consumers are concerned about the presence of natural toxicants, food additives, and microbial toxicants and their effects on the health of the consuming public. Outbreaks of food poisoning such as the 1985 *Salmonella* contamination of milk in the Chicago area, cause concern for consumers (Margolis et al., 1985). There is increasing interest in determining the impact of diet on the overall health of the American consumer. Also, as medical costs accelerate, interest intensifies in preventive measures for long-term chronic diseases. Diet is a major factor in the investigation.

fat beef and pork would be major moves in this direction. These are areas needing careful regulation to ensure that consumers receive the perceived value in food products purchased.

Consumers, who are becoming better educated on diet-health issues, are interested in buying higher-quality food products even at increased prices. The shift to more two-earner families has increased interest in convenience foods and meals consumed outside the home. More consumers demand fresh and unprocessed foods, contributing to the development of direct market outlets for fruits and vegetables. All of these concerns indicate an increasing interest in quality, variety, convenience, and safer food products by U.S. consumers.

American agriculturalists must be more sensitive to the desires and needs of its foreign and domestic consumers. A market-oriented agriculture will respond to consumers' preferences, but grading, quality, purity, and safety standards established by industry and government must be capable of transmitting consumers' tastes and preferences back to producers and marketing firms so that quality and preference are rewarded and produced.

Variety of Foods

The number of food items available in the supermarket will continue to increase over the next decade as the food industry further differentiates products and designs foods for particular market segments. Consumer demand for convenience foods, microwavable foods, low-calorie or "light" foods, natural foods, foods to support current diet fads, and fresh and gourmet foods will continue to push food companies into product development. Firms wills spend increasing amounts of advertising dollars to ensure returns on their investments in new and expanded product lines. Agricultural producers are becoming more concerned about supply and demand and marketing their products. Producer checkoff and promotion programs developed in recent years for some agricultural products will continue to promote consumption. This promotion will encourage consumers to make some shifts among food product groups but will not significantly expand overall volume of food ingredients at the farm level.

The structure of the food industry will affect the variety of foods available to the consumer. Conner (1980) and Lemaire (1985) predict there will be a dozen or so mega-international food companies by the year 2000. They will possess significant lines of food products and large product development programs, and will use saturation advertising to develop market shares for their products. Lemaire (1985) also predicts significant opportunities for the development of small, regional companies with limited product lines. Entrepreneurs will develop these small companies in niches between product lines of the giant food companies. These small companies will be creative in product development and marketing. Eventually, however, many of the small companies will be purchased by the giant companies to obtain a particular product line. Some of the entrepreneurs may come from enterprising producers developing products and direct marketing approaches to bypass the system and increase their financial returns.

New technology will influence the variety of food in two ways. First, biotechnology will make possible the development of new and different agricultural products. It will provide low-fat lean meat. It will also provide greater differentiation of raw agricultural products for such specific uses as special corn for corn flakes, nonstaling wheat for bread, soybeans producing a more stable oil, higher-protein plants, and higher-solids tomatoes for processing. Growth promotants may improve energy partitioning into more protein and less fat in meat animals. However, in year 2000 the U.S. population still will be using the same basic agricultural products of meat and fish, cereals, fruits, vegetables, and dairy products.

Second, the food processor will be able to use new processing and packaging techniques to extend lines and develop new product lines for the consumer. Consumer demand for new products related to life style changes, diet-health issues, and economic conditions will motivate the food industry to expand product and process development. The current increased interest in post-harvest technology research (U.S. Office of Technology Assessment, 1983) by both federal and state governments and the private sector will provide more fundamental research data to support product and process development in the food system.

Producing adequate quantities of farm products has been a strength of American agriculture. In the future more concern must be given to the quality and marketing of agricultural products in order to maintain the competitiveness of agriculture in the United States.

Conclusions

A number of generalizations conclude this section on the economic viability of agriculture.

1. The "best" projection is that supply will slightly outrun demand to year 2000 and beyond, bringing lower real prices, the need for exodus of farm resources, and freedom from pressure to bring new land under cultivation.

2. U.S. agricultural exports are likely to grow at rates at least as high as world agricultural export growth rates after losing ground in the 1980s. Export projections, although well below rates of export growth in the 1970s, do not indicate loss of U.S. comparative advantage although competition will be keen. Lower real input costs and exchange rates along with pressures to earn foreign exchange to service international debt will assist farm exports in the intermediate run.

3. Although the best guess is that no *strong* upward or downward trend will dominate the supply-demand balance and real farm and food prices, there is likely to be considerable annual and cyclical instability around the long-term trend. For public policy purposes, that instability is of greater immediate concern than the overall trend. A viable agriculture can adjust to persistent high prices or persistent low prices within the range of expected trends, but it can adjust inadequately and only with great difficulty to persistently unstable prices.

There is evidence of increasing variability in agricultural production. The coefficient of variation measured around best-fit linear or curvilinear time trends increased only modestly for the world from 1.5% in 1961-72 to 1.6% in 1973-83 (O'Brien, 1984, p. 12). However, variability increased substantially in many regions of the world in part because production has been extended to marginal lands more sensitive to adverse weather. U.S. export demand traditionally has been more variable than domestic demand. As export variability grows and as the share of exports in total U.S. demand grows, U.S. agriculture becomes subject to greater uncertainty. More open world trade would diminish variability in world market prices.

4. *Because of our inability to predict the future, the most important conclusion of this section is that the best strategy for economic vitality is to be flexible in being able to respond to abundance or shortfall.* Where mistakes are made—and they are inevitable—it is better to err on the side of investment in productivity to maintain comparative advantage and provide consumers with the benefit of low food prices. To err on the side of too little investment in science and conservation in a global economy could rob agriculture of its economic vitality and domestic consumers of their chance for adequate quantity, variety, and quality of safe food supplies at reasonable prices.

Projections beyond year 2000 are especially subject to large error because of the changing state of technology and of world political, economic, and social conditions. In the long run, economic viability will depend on investments in human resources, science, technology, and wise use and protection of soil, water, and other natural endowments. If the U.S. maintains its leadership in science, especially in basic and applied research in the new biotechnology, it can be at the forefront of productivity advances enhancing the U.S. competitive position, helping to preserve the environment, and providing low-cost food of special benefit to low income people. Quantity, quality, and variety of safe foods can continue to improve while real food cost declines because science is a low-cost source of future farm output.

5. Environment and Natural Resource Viability

Adequacy of Resources for Future Production

The adequacy of the resource base for sustained future agricultural production has been a recurring concern. Historically, U.S. agriculture has benefited from an abundant, highly productive natural resource base. Despite brief past periods of nearly-full use, the U.S. agricultural resource base appears to be more than adequate to meet foreseeable future needs if public policy is supportive. Some resource issues need attention. These include soil erosion, urban encroachment on agricultural lands, depletion or pollution of groundwater supplies, and quality of air.

Soil Erosion

Loss of topsoil to wind and water erosion can seriously reduce soil productivity and crop yields. Erosion reduces productivity by carrying away soil nutrients, reducing available water holding capacity of the soil, and restricting the crop rooting zone. Technology, such as the use of fertilizer and other nutrients in combination with farm management practices, can compensate for most of the productivity losses, at least in the short run. According to the 1982 National Resources Inventory conducted by the Soil Conservation Service, the national average of sheet and rill erosion on cropland was 4.4 tons per acre per year. This is roughly equal to the average soil loss tolerance level (the maximum amount of soil loss that will allow sustained productivity) of many soils. Data on average erosion rates across the nation conceal the fact that some regions have serious problems. About 44% of all cropland in the United States is eroding at levels greater than the soil loss tolerance. The most serious soil erosion problems occur on relatively few acres. In 14 intensely cropped areas in the United States, average erosion rates on cultivated cropland exceed 10 tons per acre (Lee, 1984).

Soil erosion increases both short-term and long-term farm production cost. Erosion removes fertilizer and pesticides, and decreases water holding capacity and soil fertility. Newly planted crops are damaged. Erosion costs tend to be gradual, subtle, and hence unnoticed by the farmer. They are cumulative and result in long-term costs which alter the productive capacity of soil. The depth and nature of the rooting zone are altered as topsoils developed over geological time are stripped away to expose clay, bedrock, or other root-impermeable, nonproductive materials.

One estimate of the current erosion-induced productivity losses for soil used for corn and soybean production is $40 million per year, with present values over 100 years of $4.3 billion to $17 billion, depending on the discount rate (American Agricultural Economics Association Soil Conservation Policy Task Force, 1986). These estimates do not include the costs of offsetting management practices, the costs of erosion reduction measures such as terraces, and the cost of damage to growing-crops from deposition of windblown soil.

Another study of soil productivity losses concluded that if present levels of wind and sheet and rill erosion continue for another 100 years, other things equal, productivity on soils with the greatest erosion problems nationwide might decline about 4% (Alt and Putman, 1987). Of course, productivity losses in some regions will be much larger than the national average.

Findings of Alt and Putman are reinforced by other studies. A U.S. Department of Agriculture study (1986b) used the Erosion Productivity Impact Calculator (EPIC) to simulate the effects of weather, cropping rotations, plant growth, and related processes on soil erosion over periods of 50 to 100 years. The analysis indicated that if 1982 rates of erosion continued for 100 years on the 217 million acres of land where erosion is the principal soil problem, crop yields on those acres would be 3% less at the end of the period than they otherwise would be. Improvements in technology and other factors more than offset losses due to soil erosion so that corn yields were expected to increase 76 to 102% and soybean yields 119 to 122% from 1982 to 2030—sufficient to allow U.S. land in crops to decline 30% during the period under the "most likely" scenario.[8]

Soil scientists at the University of Minnesota developed a Productivity Impact (PI) model to estimate the long-term effects of erosion on soil productivity. Pierce et al. (1984) applied the model to 97 million acres of cropland in the Cornbelt, concluding that 100 years of 1977 soil erosion rates would reduce corn yields 4%, other things equal.

Crosson (1986) used regression analysis to estimate the impact of erosion of corn, wheat, and soybean

[8] These yield projections are similar for corn but higher for soybeans than yield projections presented for 1982 to 2000 in Table 4.4.

yields using data from 91 million acres in Cornbelt and Northern Plains States. He estimated that yields of corn would fall 5 to 6% from erosion continued for 50 years at 1982 rates. Later, Crosson (1987, p. 14) concluded that the EPIC, PI, and Crosson (1986) studies "... give similar estimates of yield losses in the American midwest after 50 years of erosion. Considering the very different analytical approaches underlying the three sets of estimates, the similarity of results is impressive."

Competition Among Sectors for Land

Estimates of the acreage lost to urban development nationally have ranged from 0.9 to 1.1 million acres per year over the last several decades. Recent data from the 1982 National Resources Inventory suggest that between 1967 and 1982 the urban development and rural transportation uses increased about 0.9 million acres a year (Lee, 1984). These estimates reflect the loss of all rural land, not just cropland or agricultural land. According to estimates from the 1975 Potential Cropland Study, less than 40% of land converted to urban development and related uses between 1967 and 1975 was from prime farmland, considered by the Soil Conservation Service to be the best farmland. Not all of this land was in crops. The loss of prime farmland to urban development and related uses probably is less than 360,000 acres annually.

Concern about the loss of agricultural land has centered around the relationship between the supply and demand for agricultural land, which in turn focuses on the supply and demand for U.S. agricultural products as noted in the previous section. Estimates of available cropland supplies depend on the level and relationship between prices of agricultural commodities, the costs of land conversion, and the development of land conserving technologies. None of these relationships can be predicted with reliabilty. The 1982 National Resources Inventories indicated that, based on given price-cost relationships for each study year, 153 million acres of land have high and medium potential for conversion to cropland. Some of this potential cropland acreage is held by owners whose personal characteristics and ownership motives make them unresponsive to economic incentives for development. But much land is available for cropland development if economic conditions are favorable, even considering the annual loss of some rural land to urban development. However, the future supply of farm output will depend far more on technology and on human and material capital inputs than on shifts in land use.

Other issues have been raised with respect to the loss of agricultural or rural land. The loss of amenity values and open space in developing areas is one such issue. Loss of specialty crops in some regions has also been a concern. These issues will have important impacts at a local level, particularly where economic growth and population pressures are intense. While loss of open space or some speciality crops is not likely to affect the overall viability of U.S. agriculture, some regions or localities will wish to protect their remaining agricultural land from further urban encroachment.

Water as a Limiting Factor

Agriculture, through crop irrigation, consumes 80 to 85% of the fresh water resources of the United States (Gibbs and Carlson, 1985, p. 34). An adequate and dependable supply of water is necessary for the continued viability of agriculture in the United States. The western United States is particularly dependent on irrigation to support agricultural production. It has been estimated that more than one-half of the West's agricultural production comes from irrigated lands (Frederick, 1982). While past expansion of western irrigation was stimulated by inexpensive federally subsidized water, current and future trends suggest a very different situation. New federal water projects are limited and new irrigation water supplies will be more costly. Nonagricultural demands for water in the West have increased and will compete with agricultural uses.

Mining of aquifers, such as the Ogallala in the Great Plains, has been so extensive that higher pumping distances have made groundwater much more expensive for irrigation (Sloggett, 1985). Irrigation has become uneconomic on many areas in the Southern High Plains but conversion to dryland farming there has been offset by irrigation expansion in the Northern Plains where water supplies are more abundant. The net impact on farm production has not been large but adjustment costs of dislocation for individual farmers have been sizable.

With higher water costs and limits on developing new supplies, changes in cropping patterns and comparative advantage may occur in irrigated regions. However, management technologies to conserve water maintaining or increasing crop production will become profitable as the price of water for irrigation increases. Humid climatic areas in the East and Midwest may increase irrigation to reduce yield variability and raise production.

Most analysts do not consider water scarcity to be a long-term threat to the viability of U.S. agriculture (Frederick, 1982). However, changes in the institutional rules governing water allocation may be needed for the wise use of limited water supplies. Adjustments will be necessary in parts of the West; some farmers will face higher costs. Improved conservation and management technologies can offset some costs and help irrigated farms to remain profitable.

Water salinity will limit irrigation in some areas. An estimated 20-25% (about 10 million acres) of all irrigated land in in the United States suffers from salt-caused yield reduction (El-Ashry et al., 1985). Irrigation return flows are a major cause of salinity problems in the semiarid western states where significant quantities of salts occur naturally in rock and soils. In affected river basins, salinity has progressively increased as water resources have been developed and expanded. This trend is expected to continue unless comprehensive water quality management schemes are implemented.

Nitrate and pesticide contamination of groundwater used for crop irrigation is being detected in some areas and will increase. The impact of these contaminants on crop yields is not yet known. Potential harmful effects on yields must be ascertained. Contaminated drinking water is a major health problem and is discussed later.

Air Quality

Atmospheric deposition of pollutants can have a negative effect on agricultural production and yields. Ozone is viewed as the air pollutant affecting vegetation to the greatest extent in the United States (Heck et al., 1982). Ozone is formed by photochemical reactions involving nitrogen oxides and volatile organic compounds. By one account, ozone alone and in combination with sulfur and nitrogen oxides accounts for about 90% of air pollution associated crop losses in the United States (Gibbs and Carlson, 1985, p. 34).

Maximum ozone concentration during the growing season is in the Southeast, but ambient levels of ozone across most agricultural regions of the United States are high enough to have measurable impacts on crop yield. The annual effects on crop production from ambient ozone are estimated to be comparable to losses from pests and diseases. The economic benefits to producers and consumers of agricultural commodities from a 25% decrease in ambient ozone levels have been estimated to range from $1 billion to $2 billion (Adams et al., 1984).

Rising carbon dioxide levels could raise temperatures, raise water levels by melting ice, and shift cropping in the direction of the poles. The process is slow, not easily predicted, and in need of further monitoring. Increasing levels of carbon dioxide may enhance plant growth (Gibbs and Carlson, 1985, p. 34). No one yet can predict accurately the adverse effects of acid rain on crop productivity. Acid rain and other gaseous pollutants are not estimated to cause significant crop damage in the United States, although accurate estimates of pollutant damage are not available and further research is needed. Recently, gaseous concentrations of volatilized pesticides have been found over treated cropland in California (Glotfelty et al, 1987). Chemical reactions in the atmosphere can both reconcentrate these pesticides and transform them into more toxic substances than the original chemicals. No information is yet available to appraise the biological impacts on crops.

Agricultural Impacts on the Environment and Human Health

Concern is growing about adverse impacts of agricultural management practices and chemicals on the environment and human health. Agencies previously concerned only with on-farm productivity impacts, such as the Soil Conservation Service, are now considering off-site environmental impacts of soil erosion. The impacts of agricultural chemicals on water and air quality and food safety are attracting increasing attention from regulatory agencies, both state and federal. The exact nature as well as the magnitude of the impacts and costs of environmental damages created by agricultural activities often are unknown. Similarly, with respect to human health issues, the risks from chronic exposure to low dosages of agricultural chemicals are not readily identifiable; placing dollar values on those risks is highly controversial. The costs to farmers of regulating agricultural activities or agricultural inputs are measurable, but the benefits to society are difficult to quantify. However, methods of analysis are being improved (see Langham and McGrail, 1987). Public concern over unavoidable risks is often greater than over clearly identified, avoidable risks. Agriculture will need to adapt to public demands for lessening environmental and human health risks.

Off-Site Impacts of Soil Erosion

While concern over the productivity impacts of soil loss has existed since the Dust Bowl, study of the off-site impacts of soil erosion is relatively recent. Nonpoint widely dispersed source water pollution problems caused by sediment, animal wastes, fertilizers, pesticides, and other contaminants carried off by storm water from fields are estimated to cause a wide variety of in-stream and off-stream damages. The Conservation Foundation has estimated that the annual off-site damage costs from soil erosion range from $3.2 to $13 billion dollars. Of this, cropland's share is estimated to be $2.2 billion dollars annually (Clark et al., 1985). Wind erosion has been estimated to impose similar off-site costs (Huszar and Piper, 1986). The off-site benefits of erosion control expenditures of three major USDA programs were found to exceed the on-site productivity benefits in a recent study (Strohbehn, 1986).

These findings influence the policy perspective about soil erosion control. If productivity losses for farmers are the major concern, a voluntary program to encourage adoption and implementation of soil conservation plans might be acceptable. Apart from concerns about maintaining the quality of the resource base for future generations, any farmers who do not adopt appropriate soil conservation measures are impairing their farms' future productivity, profits, and real estate value. And if soil erosion was deemed by the public to have only a minor impact on on-site farming productivity, conservation might be viewed as a small public issue.

However, focus on large off-site damages makes a solely voluntary program more difficult for environmentalists to accept. Off-site damages impose costs on others. If voluntary programs are not effective, mandatory programs may be proposed. The Conservation Reserve provision of the 1985 Food Security Act offers incentives to remove highly erodible land from production. Another feature of the Act specifies that failure to follow an approved conservation plan on highly erodible soils by a specified date will bring termination of commodity program benefits. It is not possible to fully evaluate the impact of the 1985 Act at this point. Any successful soil conservation program will have to meet off-site as well as on-site erosion reduction goals.

Agricultural Chemicals

An emerging concern is the impact on the environment and human health of agricultural chemicals used to enhance production. Highly publicized events such as the Kesterson Reservoir issue, where concentrated salts and contaminants from irrigated agriculture in California have damaged wildlife and the aquatic environment, emphasize the sensitive interactions between agriculture and the environment. Pesticides, commercial fertilizers, and animal wastes are major contributors to nonpoint source pollution. Contaminants can reach surface waters with sediment from soil erosion. Groundwater can be contaminated in some regions by leaching of pesticides and nitrates. Irrigation and some tillage practices can further increase leaching. Residues in and on foods from pesticides, antibiotics, and adventitious additives such as hormones are a public health concern.

Public concern about environmental and human health risks is real, but the extent of damages is very difficult to assess. Studies on humans are limited, in some cases produce contradictory results, and are differently interpreted. It is difficult to prove conclusively that chronic exposure to low dosages of any chemical is a true risk factor in the development of human illness. Based on risk assessments, the Environment Protection Agency (EPA) has cancelled the use of some pesticides. More are currently under study. The *Journal of the American Medical Association* recently reported a causal association between the use of 2,4-D by farmers in Kansas and certain forms of cancer (Hoar et al., 1986). Several authors, including Fisher et al. (1987) have reviewed this study.

Risks associated with the use of agricultural chemicals are difficult to assess within a cost-benefit framework. For example, a study of groundwater contamination from agricultural chemicals estimated that it would cost private well owners in potentially contaminated counties $0.9 to $2.2 billion in initial monitoring costs to detect potential problems (Nielsen and Lee, 1987). However, the costs to agriculture of alternative management, cropping patterns, pest control strategies, or regulatory actions are unknown. Substantial data are required to compare the benefits of environmental protection with the cost of programs and policies on the agricultural sector. The public and policymakers may choose to err on the side of caution, possibly requiring the agricultural sector to choose between voluntarily implementing measures to reduce chemical impacts on the environment or face regulatory measures that will require them to do so.

Technology and the Environment

The Office of Technology Assessment (U.S. Office of Technology Assessment, 1986b) identified about 150 emerging technologies in 28 technological areas as part of a study, *Technology, Public Policy, and the Changing Structure of American Agriculture.* These technologies range from biotechnologies and regenerative and organic farming to informational systems. Most of these emerging technologies are expected to reduce the land and water requirements for meeting future agricultural output demand. The technologies are thought to have beneficial effects relative to soil erosion, wildlife habitat, and the risks associated with the use of agricultural chemicals. Yield-increasing technologies can reduce requirements for land and can permit conversion of cropland to pasture, forest, and recreational uses more consistent with soil conservation. Development of biological host resistance to pests reduced dependence on chemical pesticides. As noted by OTA, however, not all technologies will reduce dependence on chemicals. New conservation tillage technologies may reduce erosion and threats to wildlife while increasing the use of agricultural chemicals.[9] Development of new technologies will occur in a social and political atmosphere requiring environmental and public health consequences to be explicitly considered.

Recognizing Agroecosystems

The U.S. food and agricultural system is a hierarchial progression, an aggregation and integration of millions of crop and livestock ecosystems (enterprises) into farms, then communities and commodity groupings, regions, states, and finally the total dynamic national complex. Two major characteristics of integrated agroecosystems give strength and support to the long-term viability of sustainability of the overall food and agricultural system. These are (1) complementarity and synergism of enterprises for increased efficiency of output and (2) the buffering effect among the components wherein as one changes the others adjust.

[9] One-pass conventional tillage and no-till may increase herbicide use but some results (Thompson and Thompson, 1987) indicate that ridge till with reduced herbicides may reduce chemical use while increasing profit and environmental benefits.

On a farm the interrelationships within and among the individual crop ecosystems and the livestock ecosystems (Baker and Byington, 1986) are often complementary. Harwood (1982) reported that crop rotation systems based on organic principles of nutrient cycling utilize the soil nutrient accumulation from nitrogen-fixing plants to enhance production of plants with high nitrogen requirements. He also reported that cover cropping, crop rotations, and the use of leguminous crops minimize soil loss from either wind or water erosion.

The use of strip-cropping of sorghum and cotton to reduce the pesticide requirement of boll-weevil control is an example of an interaction in pest control. The Integrated Pest Management (IPM) system according to Clifford M. Hardin, "provided the least potential hazard to man, his animals, wildlife, and other components of the natural environment." IPM is used on 20 million acres yielding $578 million more annually than similar growers not using it (Canup, 1987).

An excellent example of the complementarity of enterprises is seen in the rearing of beef cattle on grazing land that would otherwise offer little productivity. Cattle from these grazing lands then move into feedlots and provide an outlet for large quantities of grain with the end result being a valuable contribution to the human diet. Animal waste returned to the soil provides a useful input for crop production. By the same token, crop refuse and byproducts of food processing can be converted into animal feeds that further add to this synergy between plants and animals.

Complementarity of enterprises is further seen in the combination of the intensive poultry enterprises with pasture production for the beef or dairy enterprises, which turns poultry waste into a useful input for the ruminant production unit. Similarly, an intensive swine unit or beef feedlot in the same farm units with corn or corn silage production shows an excellent interchange of inputs between these ecosystems. These operations are generally positive. Instances of disease transmissions, however have been noted.

Cook (1985) reported that a mix of herbivores in a diverse rangeland ecosystem increases biological efficiency because of more uniform use of the plant biomass compared to using a single animal species based on dietary variations among the animals.

Ruminant production-marketing also illustrates an agroecosystem utilizing primarily land not suited for crop production. Three-fourths of all feed units consumed by ruminants are from forage and pasture. Among agroecological systems of the future, agroforestry (combining trees, crops, and livestock) offers potential (Raun et al., 1981). One promising approach in agroforestry is producing livestock in the forest.

Paarlberg (1969) addressed the national importance of combining livestock and crops in the total food and agricultural system. He stated that "A big adjuster is livestock . . . If the food supply is reduced, we eat the livestock and then eat the crops the livestock otherwise would have eaten." Total feed grain use in this country from harvest 1974 to harvest 1975 dropped by 24% due to less feed used for livestock. Yet exports of feed grains were down by only 10%. United States feeders adjusted quickly and effectively so the impact on the rest of the world was less severe than it otherwise would have been. Wheat exports were cut more severely than feed grains, perhaps in part because there was little wheat being fed to livestock, leaving little buffer to draw on (Hardin, 1978).

In short, attention to the interrelationships and interactions among the crop and livestock agroecosystems offers significant opportunities for enhanced viability of the total food and agricultural system. Also, there are significant positive interactions between the agroecological and socioeconomic forces in the total system. Because this agroecosystem concept is somewhat of a philosophical departure from the primary agricultural focus of the recent past, special emphasis for it is necessary in research and extension to assure its maximum contribution to overall viability.

Fertilizer and Energy

Analysis (Yeh et al., 1977, pp. 46, 47) indicates that world reserves of potash are adequate for the indefinite future but U.S. supplies are rapidly being depleted. Of greater concern are world phosphate reserves estimated in 1977 to last 150 years at 1976 costs per unit. Landsberg et al. (1982, p. 81) reported estimates from the U.S. Bureau of Mines of potash (K_2O) reserves sufficient to last for 3,638 years at 1974 consumption rates and for 107 years at a consumption growth rate of 5% per year—well under the 1947-74 annual growth rates of 9.0%. The same authors reported phosphate rock reserves adequate for 128 years at a 1974 consumption rate and for 41 years at a 5% annual growth rate—well below the 7.3% growth rate of 1947 to 74.

A more recent analysis (Fantel et al., 1985) estimated that world known phosphate rock reserves will last for 245 years at 1981 annual usage. Adding to known reserves those other reserves anticipated by experts to exist, phosphate rock reserves were estimated to last 653 years at 1981 annual usage. However, the U.S. Bureau of Mines and Geological Survey projects a 3.6% annual increase in phosphate use. Applying this figure to future use, the onerous portents of exponential growth become clear: demonstrated phosphate rock reserves are adequate for only 61 years and known plus anticipated reserves are adequate for only 88 years.

Reserves do not run out; they become uneconomic to utilize. Prices rise to ration supplies as supplies diminish. Worldwide production of phosphate rock totaled 145 million metric tons in 1981. Fantel et al. (1985, pp. 20-22) estimated that 1.6 billion tons of phosphate rock are recoverable in market economies at a cost of less than $30 per ton (55% of world total reserve is in the United States), 11 billion tons are recoverable at less than $40 per ton (13% in the United States), and 16 billion tons recoverable at production costs of less than $50 per ton (21% in the U.S.)

Yeh et al. (1977, p. 47) noted that, "In the case of phosphate and potash, troublesome issues could emerge regarding availability of supplies in the face of possible international political exigencies." Massive potash reserves are in Saskatchewan; more problematic is accessibility of large phosphate reserves in northwest Africa, a region characterized by political instability from time to time.

The third principal fertilizer ingredient, nitrogen, is abundant in the air but processing requires hydrocarbons, primarily natural gas. Petroleum is also critical to power machinery and equipment and is used to produce pesticides. The productivity of U.S. agriculture depends heavily on petroleum.

The food and agriculture industry is not a disproportionately heavy user of fossil fuels—use is nearly equal to its share of gross national product. Analysts are not in full agreement but one recent study reported, "All our analyses indicate that by the year 2020 domestic U.S. oil supplies will, effectively, be depleted" and went on to add that "economic domestic (natural) gas supplies will also be depleted by 2020" (Carrying Capacity, 1986, pp. 18, 19). A report by the Rockefeller Foundation (Sivard, 1980, p. 14) indicated that world natural gas reserves are adequate to last 51 years and oil reserves 28 years at 1979 rates of use.

Not all analyses are that pessimistic but it is well to contemplate the consequences of worst-case domestic scenarios coupled with inaccessible or very expensive foreign oil and gas supplies. Several options are available. The United States has coal reserves to last hundreds of years at current consumption rates (Yeh et al., 1977, p. 47). The solid, liquid, and gaseous energy from coal could provide adequate energy supplies but at large environmental costs based on current technology. Many scientists are optimistic that safe, low-cost, abundant energy will become available from nuclear fission (the same process that powers the sun) within 100 years and well before fossil fuels are depleted.

The potential for additional life from existing sources of energy is great if account is taken of opportunities for substitution, technological innovation, and conservation.[10] With sufficient incentives, wind, solar, biomass, gasohol, and nuclear fission and breeder reactor technology also can provide energy supplies. The need for hydrocarbons can be reduced by using collectible manure, growing leguminous green manure and using legumes within the farming system, and by developing nitrogen-fixing capabilities in grasses (including grains) through biotechnology. Again, there is a basis for optimism but not complacency. The nation is highly dependent on imported energy. A strategy to maintain viability of agriculture and of the nation is to build energy reserves for meeting short-term energy crises, to provide incentives for conservation of energy for the intermediate-run, and for the long run to pursue a strong program of science and technology to develop low-cost, safe, and abundant domestic energy sources not dependent on fossil fuel. Each of these efforts can be pursued simultaneously.

Conclusions

Most analysts conclude that the soil and water resources in the United Sates are adequate to provide for future agricultural viability. If increased demands for food and fiber emerge, the cropland base can be expanded and utilized more intensively. If cost/price relationships are favorable, new technologies will be developed to increase yields and conserve land and water. Air quality changes, on the other hand, will be affected by technological changes that are predominately beyond the control of agriculture.

This national perspective ignores resource adjustment issues that could be significant at a local level. Loss of land and water for farms and local air quality problems could affect the agricultural viability of some regions. For the next decade, a major concern is how to shift millions of acres now in crops to other uses offering higher social returns. Adjustment problems will be severe on marginal cropland everywhere but especially in the Great Plains where marginal cropland is extensive and alternatives to farming limited. Excess production capacity is costly to maintain but offers opportunity for land that is erosion-prone or irrigated with nonrenewable ground water supplies to be shifted to grass, trees, or other soil conserving uses. It remains available to produce crops at a later time if the need is pressing.

Concern about the resource base extends beyond agricultural productivity. Yield-enhancing technology does not replace the need for careful stewardship of the resource base. Some resource decisions are economically irreversible. Once land conversion occurs, for example, it is difficult to return it to agricultural use. The considerable uncertainty about future technological growth and demand for resources was noted in the previous section. Use of resources now may preclude options for future generations whose tastes, preferences, and needs for resources may differ from ours. This highlights the importance of careful monitoring of trends in resources to ensure the prudent use of natural resources. Given that it is not possible to precisely match resource conservation today with needs of the next generation, it is a much less serious misstake to err on the side of conservation than to err on the side of profligate use.

The United States has met growth in domestic and foreign demand for food and fiber with essentially the same real volume of farm production inputs from 1920 to the present. The source of increased output or new wealth was not natural resources or raw labor but increased productivity from creation of knowledge through human ingenuity, education, research, science, and technology. The result has reduced pressure on soil and water resources.

Sharply raising farm commodity prices or substantially curtailing soil erosion and conversion of cropland to urban uses are costly and not effective means by themselves to respond to emerging food and fiber needs. As noted above, there is merit in preserving agricultural land for option value and other reasons. But the lowest environmental cost and overall economic cost strategy is to invest in development of new agricultural technology to raise farm productivity to meet demand for food and fiber with minimal pressure on natural resources and the environment. Another alternative is to scale back living standards, an alternative only a few Americans are likely to accept.

[10] Another dimension of energy and mineral conservation is composting and processing of city wastes. A beneficial interaction can make the farm and city more viable, with hinterland farmers, many of them of small size, finding and serving niches in city markets overlooked by conventional markets.

6. Social Viability

This section on social viability is divided into three subsections. The first briefly reviews farm structure, the second human resources, and the third farm-community interaction.

Farm Structure: Situation and Trends

American agriculture is heterogeneous. According to the Census of Agriculture (U.S. Bureau of the Census, 1983, p. viii) the nation's 2.24 million farms in 1982 averaged 440 acres in size, $346,000 in real estate value, and $59,000 of annual sales. However, nearly one-fourth of these farms sold less than $2,500 in farm products per year and one-half of them sold less than $10,000. Five percent of all farms account for half of farm output; half of all farms account for 5% of farm output. Only about 300,000 farms, or 13% of the total, had product sales of $100,000 or more in 1982.

The midsize full-time family farm, perhaps the closest institution today to the Jeffersonian ideal, is being squeezed between growing numbers of small part-time farms and large industrial-type farms. The number of farms under 50 acres in size increased by almost 17% between 1978 and 1982 and account for nearly 30% of all farms. Large farms also expanded in number. The number of farms with sales over $100,000 per year expanded by 50% between 1974 and 1978 and by over 35% between 1978 and 1982. Although they currently comprise only 13% of all farms, they account for nearly three-fourths of all farm production.

Ownership

The overwhelming number of U.S. farms—nearly 90% — are independently owned by unicorporated individuals or families. Unincorporated partners account for most of the remainder. Only about 3 of 1,000 farms are nonfamily corporations and only one of 2,000 farms is a nonfamily corporation with 10 or more stockholders. The proportion of noncorporate farms owned by individuals and families remained quite stable between the 1978 and 1982 agricultural censuses. Foreigners own less than 1% of America's farmland.

About 60% of the farms are full-owner operated. Part-owners operate nearly 30%. Tenants, or renters, run nearly 12%. Nonfarmers owned 36% of farmland in 1982, the same proportion as in 1978 (Tweeten, 1984, p. 13). About half of these nonfarmers were retired farmers or their spouses. When farms fail financially or are sold for whatever reason, they are purchased by family farmers in most cases.

Concentration of Land Ownership

The opportunity to own a farm, especially for individuals who are not farm heirs, and the extent to which farm heirs can expand their farming operations, is directly related to the availability and accessibility of farmland. While almost seven million farmland owners would appear to be a sufficiently large pool to ensure a fluid and competitive market for land, it should be noted that 1% of the farmland owners control over 30% of the private land in the United States and the largest 5% holds almost 50%. Thus farmland ownership is concentrated similar to agricultural commodity sales. Net income from all sources, net worth, and human resources are more evenly distributed among farms than are land ownership or farm income. Operation and ownership of commercial farms will trend to greater concentration in the future but at a slow pace.

Only about 3% of farmland changes hands in any given year. Furthermore, the USDA estimates that about half of this 3% never makes it to the open market. Instead, it is transferred through inheritance, as intrafamily gifts, or by private purchase from relatives. In addition, a proportion of the 1.5% that is ostensibly offered for sale to outside investors or young farmers is, in fact, transferred through prearranged sales to friends and neighbors.

Several factors explain why farming opportunities are limited for potential farm owner-operators. Among these are economies of size with attendant tendencies to purchase farms for consolidation, and the family farm structure characterized by the operator holding title to land during his working years to be followed by a family member taking over. Most economies of size are realized by family size farms. But for many types of farms and for the farming industry as a whole, economies in production or marketing (input price discounts, product price premiums) extend beyond traditional family size farms (Tweeten, 1984, p. 22; U.S. Office of Technology Assessment, 1986b). A typical pattern among farm types is for cost per dollar of sales to decline 5 to 10% for units with annual sales over $250,000. Few potential young operators have the resources to begin on such units.

Human Resources

Operator Characteristics

Seventy percent of farm operators live on their farms. Farm operators average a little over 50 years of age and 17 years on their present farms. Women operate just over 5% of the farms while blacks operate 2.4% (Wimberley, 1986, p. 97).

During the last five censuses, the mean age of operators has ranged from 50 to 52. The average age of farm operators dropped from 1978 to 1982 but rose in the 1980s as many potential young operators were discouraged by depressed economic conditions from entering farming. Also, many young operators who purchased land in the 1970s were unable to survive financially in the 1980s.

Principal Occupation

The last three agricultural censuses asked farm operators whether farming was their principal occupation. Numerically and proportionately, fewer see themselves as farmers each year. By 1978, this percentage already had dropped to below half of the farm operators and the proportion continues to drop slowly. Part-time farming has become the career pattern for about half of the farm operators in the country (Wimberley, 1986, p. 117).

Another way to classify full or part-time farming is according to the time an operator works away from his or her farm. Fully 53% worked off their farms for some of the year; 35% worked away at least 200 days. Whether measured by proclaimed occupational identification or days worked off-farm, U.S. food and fiber is being supplied by as many part-time farmers as full-timers. But these part-time farms account for relatively small proportion of farm output. Family farms in the $40,000 to $250,000 sales category where few operators work off the farm accounted for one-fourth of all farms and two-fifths of all farm output in 1985.

Hired Labor

Just under 4 of 10 farms hire labor—1.3 million hired workers nationally at a cost of $8.7 billion. Another $1.6 billion goes to contract labor plus $2.2 billion for custom work and machine hire.

The trends in hired labor use are mixed. The number of farms having hired labor has decreased. Only half as many farms had hired labor in 1982 as in 1964. Numbers of hired workers are up but hours per worker are down because an increasing proportion are part-time workers. Total labor performed by hired workers has declined and the ratio of hired labor to family labor has not changed appreciably for two decades.

Beginning Farmers

Beginning or entering farmers are defined as operators under 25 years of age. Of course, entry into farming is not restricted to this young age cohort, but virtually all farmers under 25 years old are recent entrants and thus can be considered "beginning" or "entering" farmers.

The average farm size for entering farmers decreased from 1978 to 1982 but remained stable for established cohorts. Established farmers operated larger farms than entering farmers in both years. The notion of a dual agricultural structure finds support from the findings that almost half of the entering cohort in 1982 began farming on less than 100 acres while only 10% began operating 500 or more acres. Furthermore, almost half of the entering cohort has gross annual sales of less than $20,000. The average amount of agricultural sales per farm for the entering farmers in 1982 was 39% less than the average amount of agricultural products sold on established farms.

Entering farmers are more likely to hold off-farm jobs than established farmers. Almost 65% of the entering cohort in 1982 reported working off the farm compared with 53% of the established cohort. Off-farm employment may serve as a means of accumulating resources needed for entry into full-time production agriculture. Results of farm surveys (Sanford et al., 1985) indicate that farms grow in size over their life cycle but there is relatively little crossover between part-time small farms and full-time commercial farms. Farms starting small tend to stay small; farms starting large stay large. Persons who enter farming on a part-time or limited-resource basis do so with little expectation of becoming full-time commercial operators. These patterns lend support to the observation that American agriculture is slowly becoming bifurcated into a larger farm, commercial sector, on the one hand, and a small scale, limited resource, and part-time sector on the other. The trend to large farms has been more rapid for cotton, sugar, livestock feeding, and processed fruit and vegetable production than for grains and soybeans.

Family Farming

A principal advantage of family farmers—high-quality operational management and husbandry coupled with willingness to temporarily postpone consumption or accept low returns on owned resources—is relatively less important for survival today than in the past. More important than in the past is organizational management apparent (1) in wise use of diversified sources of farm or nonfarm debt and equity capital and of income, (2) in achieving marketing and production economies, (3) in asset portfolio manipulation, and (4) in use of sophisticated technology (for example, computers), risk management strategies, and paid consultants. Family size farms have had difficulty maintaining first-rate organizational management. An unstable agriculture apparent in the 1970s and 1980s increases the comparative advantage of firms which can most efficiently manage risk and adjust to disequilibrium.

Approximately 50,000 or 2.3% of all farm operators retire or die each year. Relatively few established farmers leave farming before retirement. Even in the difficult 1980s, those forced to exit were replaced by new entrants so the average net decline in farm population and numbers could be largely accounted for by death or retirement of operators. Farm numbers declined by 1.6% per year from 1980 to 1985 (U.S. Department of Agriculture, 1986a, p. 13). The 2.4% annual decline in farm population in the first half of the 1980s was approximately half the rate of decline experienced in the 1950s and 1960s.

Although the comparative advantage of the corporate industrial-conglomerate farm has increased relative to the family farm in the last decade or two, family farms of all sizes, with the help of generous parents of young operators, are being passed from one generation to another. They have shown remarkable resiliency. Without generous assistance from farm parents who establish sons and daughters in farming, the middle- to large-size family farm might disappear in a generation. But farm parents will continue to help offsprings get started in farming—the family farm will be as permanent as the generosity of parents. The mid-size family farm will be around for generations to come but in diminishing numbers and proportions of all farms. The inroads of the corporate-industrial agriculture are slow.

Tax advantages, subsidies to rural services, and amenities of rural living make part-time small farms attractive even though economic efficiency of such farms is low as measured by the opportunity cost of resources relative to returns. These part-time family farmers have resilience in the face of an unfavorable farming economy because in most cases farm income is a small proportion of their substantial total income. Their off-farm income supports their farming operation. Small, part-time family farms not only are numerous but are growing in numbers. Thus the future of the family farm is assured.

Table 6.1 from the Office of Technology Assessment projects farm numbers to year 2000. The number of large farms with sales over $200,000 per farm is projected to increase from 121,700 in 1982 to 175,000 in year 2000, a 44% increase. The number of moderate-size farms with sales of $100,000 to $200,000 is projected to decline from 180,700 in 1982 to 75,000 in 2000, a 58% decline. And the number of farms with sales less than $100,000 is projected to fall from 1,939,900 in 1982 to 1,000,200 in 2000, a 48% decline. Overall farm numbers are projected to fall 44% by year 2000.

The OTA projections may be realistic for large farms but when compared to past trends appear to be overly pessimistic for medium farms and especially for small farms. The overall rate of decline projected for 1982 to 2000 is 3.2% annually, a much higher rate than occurred from 1950 to 1982 (2.6% annual decline) or in the financial stress years of 1982 to 1985 (1.6% annual decline).

Farms operated by full-time persons under age 65 once dominated small farm numbers. Studies show that part-time farmers are increasing in numbers and dominate on farms with sales of under $20,000 (Tweeten, 1984, p. 11). Their dominance is extending to larger (but still small) farms. Thus small farms are unlikely to decline at rates projected by OTA. Overall numbers of farms are expected to decline no more than 2% per year on the average in the future and the absolute decline will be a small fraction of that experienced in the 1950s and 1960s. Of course, a change in definition of what constitutes a farm would markedly change "farm" numbers.

Table 6.1. Most likely projection of total number of U.S. farms in year 2000, by sales class (U.S. Office of Technology Assessment, 1986b, pp. 16,17)

	1982				2000	
Sales class	Sales per farm	% of all sales	Number of farms (thousands)	Percent of all farms	Number of farms (thousands)	Percent of all farms
Small and part-time	<$99,999	27.3	1,936.9	86.0	1,000.2	80.0
Moderate	$100,000-199,999	19.2	180.7	10.0	75.0	6.0
Large and very large	$200,000 +	53.5	121.7	4.0	175.0	14.0
Total		100.0	2,239.3	100.0	1,250.2	100.0

Quality of Life

Family, home, and work are more closely interwoven for farmers than for people in other vocations. American farmers are strongly attached to their way of life and committed to their work (Wilkening, 1982). The bond between the farmer and his or her work is stronger than for nearly all other types of occupations. The intermingling of work, family, and way of life in the family farm magnifies the emotional trauma of farm failure. This attachment to farming is strong whether the involvement in farming is full-time or part-time, large or small. Data show that the decision to leave farming is traumatic but that most people feel favorable toward the move after they have had time to adjust to new circumstances (Tweeten and Brinkman, 1976, pp. 88-92).

Farmers are more satisfied with their way of life but are more unhappy with their economic circumstances than are persons in other occupations (Campbell, 1981; Coughenour and Tweeten, 1987). Thus, farmers are no more satisfied or happy as a whole than those in other occupational groups. The relatively high satisfaction with farming itself is not generally linked to the type of farm. Satisfaction is higher on medium-sized or full-time farms than other types of farms but differences are not large and are overshadowed by life cycle stage, level of education, and overall family income (Molnar, 1985, p. 143).

The issue has been hotly debated whether the family farm must be preserved to maintain a viable agricultural production plant and, indeed, a viable nation culturally and morally. That debate does not appear to be fruitful for several reasons. First, as noted above, the long-term viability of the family farm is not in doubt although the number of midsize farms will decline.[11] Second, although social and moral differences between farm and nonfarm people may be real, those differences are becoming smaller and even insignificant as values converge. Farm people excel in some attributes while nonfarm people excel in others, and to say which overall set of attributes contributes most to America requires a judgment this Task Force cannot make on an acceptably objective basis. Finally, even if farm people were judged to be a wellspring of moral and social vitality for the nation, the numbers are simply not there to make a decisive difference. The farm population numbered only 5 million or 2% of the nation's population in 1987. The economic vitality of the farming industry is not uniquely tied to any one of the numerous farm types or sizes found in agriculture.

Farming and Rural Communities

Defining agricultural counties as those with 20% or more of labor and proprietors' income from agriculture, 27% of all nonmetropolitan counties and 12% of all nonmetropolitan people were in such counties in 1980 (Deavers and Brown, 1985, p. 9). That means that the economic base of many but by no means a majority of rural people is farming. A declining share of rural communities depends on agriculture but dependence is especially high in the Great Plains and western Cornbelt.

Especially in agricultural counties, fewer and larger farms may lead to changes in the local economy, changes in the local social structure and politics, and

[11] Family farms are here defined broadly to include (1) part-time farms and (2) large farms where most of the management and equity capital are provided by the operator and family. Such farms are growing in numbers. Midsize, full-time farms are family farms and are slowly declining in numbers. But they will be around for many generations to come because farm parents on such farms give sons and daughters a start in farming.

changes in local institutions. The strongest form of this thesis was put forth by Goldschmidt (1978) based on a case study of two California communities. He and others have stated that independent family farms create healthier rural communities and that the loss of such farms creates detrimental social and economic impacts. As farms increase in size and decline in numbers some of the losses in local small community service capacity are redistributions within regions to service centers better able to support larger, more complex firms. Furthermore, an increase in part-time farming may cushion some of the economic impacts and population shifts associated with farm consolidation.

The cost structure of the farms by size is a critical factor determining the form and long-run viability of the farming enterprise. For the family on a limited-resource farm or an unprofitable farm committed to maintain farming as a life style, or for the beginning farmer unable initially to service cash flow, off-farm income is essential to maintain the farming unit while achieving an acceptable standard of living for the family. It follows that off-farm income opportunities influence the viability of farms. In a growing number of instances, the community influences the viability of local agriculture as much as agriculture influences the community.

Conclusions and Policy Options

Estimates of comparative advantage and projections of future supply-demand trends, though helpful, independently are inadequate to appraise long-term viability of agriculture. It is indeed tempting to forecast decades into future, then carefully plan for the required acres of cropland and investment in irrigation and soil conservation.

Such central planning, however, has a mixed record at best. Unfolding events overwhelm our capabilities to predict. The long-term viability of U.S. agriculture ultimately rests not with our ability to rigidly plan or shape a knowable future, but instead rests with a public policy of resiliency and flexibility to respond to an unknowable future.

The current United States international trade position is unsustainable. The nation is consuming much more than it produces and has become the world's largest debtor in doing so. That foreign debt will have to be serviced by exports. Because of favorable natural and human resources, infrastructure, and technological prowess, U.S. agriculture can be near the forefront of exporting industries.[12] Labor productivity and multifactor productivity have been increasing faster in agriculture than in other U.S. industries on the average. Agriculture is among the nation's most capital- and research-intensive industries — a "high-technology" industry capable of meeting world competition.

International leadership in agriculture is not assured if public policy neglects to do what the market will not do. According to the National Science Board (1983), research spending on agriculture as a proportion of total nondefense research is higher in Japan, France, and several other nations than in the U.S. Productivity gains from technology will slow without proper funding of research and education.

Technology Development

The single most important ingredient to ensure long-term viability of agriculture is continuing investment in science and technology for maintaining comparative advantage, for contributing to earning of foreign exchange to pay for imports, and for providing safe, abundant, high-quality food supplies at low cost to consumers and at acceptable social and environmental costs to producers and society. Such a policy is part of the overall economic strategy of ensuring a long-term viable agriculture by allocating resources where social returns are highest.

At a time when worldwide grain surpluses have become a political liability and the debates continue as to the impact of various new technologies on the farming infrastructure, it is not surprising that support for U.S. agricultural research is fragmented. The largely pro-technology attitudes of the 1960s and 1970s fueled by fears of population growth and world hunger have been replaced by concerns over the commodity surpluses, health, safety, and environmental aspects of agricultural technologies. The apparent conflicts that exist in current agricultural and science policy over issues such as free trade versus price supports, basic versus applied research, public versus private

[12] The U.S. aircraft and high-technology electronics industries may have greater comparative advantage than agriculture. But the aircraft industry is experiencing greater competition from Europe and the computer industry from Asia and Europe. Thus these two industries can earn sufficient foreign exchange to pay for only a portion of U.S. imports and debt service.

funding, and conventional versus low-input farming practices also may have diluted support for agricultural research.

Paradoxically, the growing ambivalence towards the need for agricultural research is prevalent at a time when promising new biological and informational technologies offer opportunity for substantial enhancement in agricultural efficiency, reduction in farm production costs, protection of the environment, and generation of new market opportunities. We are entering a period when science has the potential to impact agriculture as significantly as past farm mechanization, the development of hybrid crops, and the use of agrichemicals. Genetic bioengineering techniques still in their infancy allow for the rapid introduction of genes carrying new traits into plants and animals. Already scientists have produced plants with superior viral disease, insect, and other pest resistance properties (Fraley et al., 1986) and animals with superior performance as a result of hormones and vaccines. Equally dramatic advances in computer-based monitoring and information transfer systems have provided growers with direct, rapid, and timely information for decision making.

In developing a strong pro-agricultural technology position in the context of controversy surrounding various social, political, and science policy issues, it is important to emphasize the need for efficient transfer and proper management of new technology, as well as to emphasize the benefits of the technology itself. Food will always be a strategic necessity; we must ensure that this need will be met under foreseeable circumstances. We need to make sure that the technologies are properly focused on tomorrow's needs and that the potential social and environmental benefits of a new technology are anticipated and realized. At the same time, we need to more fully understand the potential negative aspects of new technologies and determine both the losers as well as the winners—and plan and act to minimize the negatives.

Technology for Enhanced Production Efficiency

Simply stated by James Bonnen of Michigan State University, "A mature industrial nation's comparative advantage in international markets rests on high technology and high human capital . . ." U.S. agriculture will face growing competition for international and domestic markets from countries with developing production capabilities and cheap labor pools as well as from those countries with strict trade policies. As a result, the future competitiveness of U.S. agriculture will depend more on the proper development, transfer, implementation, and management of technology than in the past. This is a strong statement considering the remarkable fact that through technological advances the demand for U.S. farm output in 1986 was met with essentially the same real volume of production inputs as was used in 1920.

With the recent emphasis that has been placed on falling grain prices and overproduction, many have lost sight of the fact that during this period the tremendous gains made in production efficiency have enabled well-managed farms to earn returns comparable to businesses in nonfarming sectors of the economy. The improvements in production efficiency, more than price supports or any other government programs, have allowed U.S. farmers to compete in international markets. And improvements in production efficiency are the product of teamwork between science, industry, and farmers.

Continued emphasis on development of technologies which lower production cost per unit of output (not necessarily increased production) is strategic to maintaining a viable and flexible U.S. agricultural system. Numerous independent analyses (Ruttan, 1982; Braha and Tweeten, 1986) indicate the return on investments in agricultural research generally exceeds that of other publicly funded projects. Nonetheless, maintaining aggressive public funding of agricultural research in the midst of production excesses and cyclical farm policies has met with only partial success. In part, this results from claims that scientific and technological advances are the cause of today's excess capacity and financial stress.[13] In reality, these problems are caused by domestic and international macroeconomic, trade, and farm commodity policies which influence demand and input prices and which create cycles of economic expansion and contraction. A key concern is that impetuous reactions disrupting stable, long-term funding interfere with the development of new technologies, because these are particularly vulnerable to cutbacks. At any point in the future we must have the flexibility in our agricultural production system to increase outputs in response to unexpected changes in our needs; this will only be possible if we make and protect today's investment in agricultural research.

[13] The parity ratio (ratio of index of prices received to index of prices paid by farmers) was 52% of the 1910-14 ratio in 1985. But aggregate multifactor productivity (output per unit of production inputs) was 278% of the 1910-14 average in 1985. Hence, product price per unit of production resources was .52(2.78)(100)=145% of the 1910-14 average in 1985!

Federal research funding especially has lagged and is vital to basic and applied research which benefits society as a whole but provides too little benefit to any one state or private firm to justify that state's or firm's funding.

Technology for Increased Market Orientation

Value-added and quality enhancement have been important aspects of the U.S. food system and the trend will continue with increasing emphasis towards healthful foods, prepared meals, and meals eaten away from home. "The food industry has moved from selling the commodity, to selling the partially formulated product, to selling the wholly formulated product. As an example, first came flour, then cake mix, and then ready-to-eat cakes," says Dr. Dee Graham at Del Monte.

Market segmentation will become increasingly important as consumers demand a wider array of specialty and dietary food products. New techniques for preparing, preserving, and packaging food give food scientists a diversity of tools to provide consumers with the products they want. Improved education and grading systems can help the market to signal consumers' wants more accurately so that producers and the food industry can respond accordingly. The public sector needs to work with industry to improve quality and grading standards and consumers' education.

Responding to the market has had a major impact on the food processing industry, but has had less significant impact on the overall U.S. agricultural production system. In part this has been because past emphasis has been on production levels and quotas rather than on quality and market needs. Today's research emphasis needs to be refocused and targeted to enhance grain and food quality, support market segmentation, and address unmet needs in international agricultural markets. Today's technologies (including development of new crops, alternative crops, and the use of biotechnology and plant and animal breeding to enhance nutrition, taste, and other quality parameters) need to be strategically focused on the production of differentiated, value-added farm products. In addition to emphasizing value-added food products, enormous opportunity lies in the successful exploitation of crops for energy, industrial feedstocks, and specialty chemical production.

Mechanisms for Efficient Technology Transfer

U.S. agriculture has remained viable and at times thrived economically due to adoption of technology developed through publicly funded research and transferred to producers through the agriculture extension service as well as by private agricultural firms. The extension service has been praised for its efficient technology and information transfer from researcher to end user. Technology and information transfer will be as crucial for the future viability of U.S. agriculture as it has been in the past. The mechanisms for efficient technology transfer, however, are changing, and the future extension service, while maintaining its present mission, will not likely have the same structure and type of audience as in the past. Several developments are driving this change.

—Advances in the technology of information gathering, exchange, and processing will force extension into new roles and likely away from the researcher/specialist/county agent/farmer hierarchy that has characterized technology transfer in the past.

—Private industry is increasing its focus on technology transfer to the farmer. Many of the production practice recommendations that extension traditionally developed and communicated to farmers are being offered to the farmer by private industry. This trend is likely to continue and expand as firms compete on the service as well as on the product side. Extension can view this change either as the entrance of a new competitor or as the opportunity to expand its clientele to include private crop consultants and industry representatives.

—The gradual trend toward a relatively few large farms accounting for most farm output and toward part-time small farms accounting for most farms requires adaptations in extension education. It is beyond the scope of this study to specify precisely what those adaptations need to be. But simply continuing traditional approaches will not serve the needs of part-time small farms nor of large commercial farms.

Minimizing Potential Negative Impacts of Technology

New technologies have historically had a significant impact on structural changes in agriculture. The cause of these structural changes appears to be as closely related to access to the technologies and information as to the technologies *per se*. Although most agricultural research and technology development is not inherently biased toward large-scale farms, lags in adoption by small- and moderate-size farms have the effect of a bias. It is expected that, in terms of emerging technologies in crop and livestock production, the largest farms will adopt the greatest amount of new technology (70%) compared to only 10% for small, and 40% for moderate size farms (U.S. Office of Technology, 1986b, p. 134). The economic advantage that accrues to early adopters is also expected to favor operators of large farms.

The OTA report concludes that moderate- and small-size farms will depend greatly on publicly sponsored research and extension education to gain access to new technologies and to adapt them to their individual needs. One important strategy for maximizing the scale-neutrality of new technology is to provide more equal access to the technology through the directed efforts of extension service.

Technology Advances for Resource Conservation

Another important issue is how to direct technology advances to enhance and conserve natural resources. Some critics of the present research/education system have suggested that technological advances in agricultural production have led to a decline in the quality of our soil and water resources. Whatever the case, there is merit in supporting those technologies having the greatest potential to efficiently produce food, feed, and fiber, and having the least negative impact on our natural resources. These technologies are available—in fact, most new technologies are expected to reduce land and water requirements for meeting future agricultural needs (U.S. Office of Technology Assessment, 1986b). These technologies can reduce soil erosion, environmental pollution, and threat to wildlife habitats. Examples of beneficial technologies include:

—Increased use of biological nitrogen in cropping systems. Greater use of forage legume rotations in U.S. cropping systems has the potential for maintaining productivity and conserving our resource base at the same time (Aldrich et al., 1980). Current U.S. farm policies, by creating incentives for farmers to plant nondiverted acreage in crops in order to feel assured of maintaining their crop base, provide a disincentive for crop rotation with legumes or conversion of fragile lands to grasses, trees, and other soil conserving uses. Development of plant varieties requiring less application of commercial phosphate can also be important in view of the data reported on depleting phosphate reserves.

—Biotechnology for plant improvement and crop protection. A key focus of agricultural biotechnologies is to understand host-pathogen interactions so as to interfere with disease development or pathogen replication. The application of genetic bioengineering to modify crop plants to resist insects and diseases has already been demonstrated in the laboratory and has significant potential as a pest control strategy.

—Emphasis on the development of environmentally safe agrichemicals. Growing public concern over the use of agrichemicals in crop production has resulted in the chemical industry's focus on discovery and development of new products which are effective at much lower application rates (ounces per acre instead of pounds) and which are intrinsically less toxic. These features have become as important or more important than product efficacy itself.

—Some farmers have increased profitability by cutting costs while even possibly decreasing output. To cut costs, farmers can: (1) diversify by using more complex rotations and adding animal enterprises; (2) cut pesticide inputs to economic thresholds; (3) adapt soil- and money-saving tillage practices without herbicides; and (4) use nitrogen-fixing legumes as cover crops and in rotation to help decrease the need for purchased nitrogen fertilizer. One way for farmers to stay flexible is to reduce their input costs and diversify their operations. And one way to reduce potential risks of agrichemicals is to use less of them. For example, banding herbicides over the row and cultivating can substantially reduce the amount of herbicide that has the potential of getting into groundwater. These practices are particularly appealing when they are more profitable than other practices.[14]

[14] Benefits of on-farm research and farmer-to-farmer education on these practices can be substantial. On-farm research can be relevant (farmers design the experiments to answer their own questions), practical, and observable because it's done on a field scale. In addition to being low-cost, on-farm research can complement university and private research with simple experimental designs that are satisfactory to both farmers and statisticians. The Rodale Institute had 12 on-farm research cooperators in the Midwest in 1987. Practical Farmers of Iowa had 13 on-farm research and demonstration sites in that state. In 1988, it will be expanded to more than 20 farms. The Land Stewardship Project in Minnesota, the Wisconsin Rural Development Center, and the Center for Rural Affairs in Nebraska, and others also are conducting on-farm research programs.

A problem with past investment in science and technology is that increased productivity and substitution of improved capital inputs for labor has diminished farm numbers. Although simultaneously investing in agricultural science to increase productivity while paying farmers not to produce and supporting farm income can have a favorable net economic payoff to society as demonstrated by Braha and Tweeten (1986, pp. 24-27), selected actions can be taken now to lessen unfavorable impacts of technology on farms.

One such action is to place more emphasis on resource-neutral and on cost- and resource-saving technology versus output-increasing or scale-biased technology. Today's examples are conservation tillage, integrated pest management, and integrated reproductive management. Tomorrow's examples may be nitrogen-fixing or pest-resistant corn or wheat plants and, in animals, genetic resistance to disease developed through the new biotechnology. Research on new plants and on animal products to serve entirely new uses or uses now served by nonrenewable resources (such as oil or phosphate) are other examples.[15] This report does not attempt to prescribe detailed management of agricultural science and technology policy. Specific measures are important, however, such as private and public initiatives to inventory and maintain the world's germplasm as a foundation for improving and developing new biological sources of food, fiber, and fuel.

Private-Public Sector Cooperation

The private sector is taking increasing initiative in basic and applied research and development of new technologies. However, the private sector alone will underinvest in basic research because the market (despite patent protection of biological life forms) is unable to appropriate sufficient benefits relative to development costs despite very high social benefits-cost ratios. Because benefits spill over state boundaries, highly favorable benefit-cost ratios for the nation as a whole can be unfavorable ratios for investment by individual states. The public sector continues to play a critical role in basic research and in some fields of applied research. The federal government needs to provide a greater level and proportion of funding for agricultural research to obtain optimal investment.

It is important for agricultural science to be open to ideas. The agricultural scientific establishment has a proud record of accomplishment in generating ideas. But American agriculture also has a rich tradition of the individual tinkerer, inventor, and general innovator—sometimes ahead of the scientific establishment in originating ideas. Many such persons are experimenting with alternative ways to grow crops, husband animals, conserve the soil, use fewer purchased inputs, and protect the quality of food and water. Scientists in research establishments share many of the alternative agriculture objectives—protecting the environment, safe food supplies, concern for farm people, and avoiding excessive input use.

All too often there has been needless animosity between the scientific establishment and such innovators. Such animosity poorly serves agriculture and society, closing off opportunities for interaction between the two groups which could make each more effective and useful. Investment in science and having a safe environment can be viewed as complementary objectives. Investment in science and technology, especially the new biotechnology, can simultaneously provide safer and lower cost foods and while doing a better job of protecting the environment. Pest resistant crops can reduce requirement for pesticides. Land-and nitrogen-saving crops can allow less use of nitrogen and allow more cropland to be converted to grass, trees, and recreational uses.

Land-grant universities and federal researchers can benefit from insights into low-input farming gained by independent experimenters and would do well to test advantages and disadvantages of these promising new technologies and practices. At the same time, private innovators can benefit from working with scientists and their apparatus, and can work with the Cooperative Extension Service to spread knowledge of what technologies and practices work best to produce safe, low cost, quality foods while preserving the environment.

Other Issues

Agricultural science and technology investment decisions take place well in advance of outcomes. Braha and Tweeten (1986, p. 9) estimated that a dollar invested today in agricultural production research and extension has its peak output in eight years but continues to contribute to productivity for 16 years on the average. Given the high payoff on past investment and the long lag times, the appropriate policy is to invest on the basis of the best information

[15] See the CAST Task Report (R102) on *Development of New Crops: Needs, Procedures, Strategies, and Options.*

available.[16] Decisions made in 1988 will influence productivity beyond year 2000.

Other Policy Options

Not all public policies and private institutional initiatives equally equip the nation to cope with emerging realities. In some instances, the best public policy is to rely on private initiative. The following options are intended to bring out the best in both the public and private sector to maintain the long-term economic, social, and environmental viability of agriculture.

1. The nation faces two broad choices in commodity program and trade policies. One option is to place its trust in high rigid price supports and mandatory production controls with producers safely protected from world competition behind high-tariff walls. Under this scenario, investment in agricultural science and technology would have low payoff and low priority because benefits merely would be bid into land values to enrich landowners. Allotments would grow smaller each year because even slow growth in productivity would outpace demand growing only 1% per year from domestic sources alone. Protective tariffs insulating farmers from world competition would ensure an absolutely declining farming industry because domestic demand would increase more slowly than productivity. Such an agriculture would not earn foreign exchange to service international debt or to purchase needed imports. If other economic sectors and nations followed the pattern of U.S. agriculture, the result would be a world of autarchy and economic stagnation.

Another option is to recognize that the United States is now a part of the global economy of integrated commodity and capital markets, that economy needs institutional change to work better, but that U.S. agriculture can compete in the world market and contribute materially to national and international economic progress if supported by appropriate scientific, macroeconomic, trade, and commodity program policies. The long-term viability of agriculture is served not by building rigidities into the system to protect farmers but by designing an institutional framework to respond to the exigencies of surplus or abundance, of changing consumer tastes, of shifting demands, and of a changing world order. Arbitrary rule changes are to be avoided, but a flexible long-term policy is essential. Exposure to vagaries of nature and markets around the world makes life less comfortable and far more challenging to farmers, but our farmers are quite capable of competing, making a profit, earning foreign exchange, and protecting the environment—all while relying mainly on the family farm structure of agriculture.

That American agriculture is far too vast, complex, and dynamic to be centrally planned and administered is dramatized by worldwide failure of such attempts. The appropriate approach in such circumstances is to rely on the market to the extent possible, but for government to supplement where the market does not function well. Examples of such tasks are provision of basic research and information, establishing grades and standards, protection of the environment, safe food and water, building and maintaining infrastructure, providing for those incapable of providing for themselves, and maintaining workable competition in the private sector.

2. Good intentions notwithstanding, it is necessary to recognize that it is exceedingly difficult to develop cost-reducing technology (helping to keep the United States competitive in world markets and helping the world meet its food needs at low cost to consumers) that is not output-increasing. Improved crop varieties and animal species, for example, reduce costs of production but they also tend to increase output and advantage early innovators—who happen to be larger then the typical farmer on the average.

It is neither possible nor desirable to totally separate policies keeping agriculture viable environmentally and economically from policies to accomplish social objectives such as to preserve family farms and rural communities. But caution is suggested. For example, serving social objectives by focusing public research unequally on small farms (accounting for most farms but a small portion of all farm resources and output) is likely to forego benefits from safer food at low cost to society and benefits from foreign exchange earned because of ability to compete in international markets. Much research and technology in the past and in the future will be suitable for a wide range of farm sizes; family farms, many of them small in size, will continue to display initiative in production of high-value crops tailored to specific local markets.

3. Other than for modest efforts such as the Conser-

[16] Braha and Tweeten estimated the optimal rate of real increase in public agricultural research investment was 4% per year on average but with a higher rate in early years and a lower rate in later years. Investment decisions must continually be reviewed and revised, however.

vation Reserve discussed elsewhere in this report, it is no more advantageous to hold excess capacity for extended periods in farming than it would have been to maintain the horse buggy or steam locomotive manufacturing industries. If the market will not support farm resources, then downsizing of the agricultural plant is appropriate.

If a strong program of training and mobility assistance is available, it is feasible to more aggressively enhance productivity growth in agriculture while minimizing adjustment problems for those impacted. Continued application of science to agriculture—so essential to maintain comparative advantage and contribute to national economic progress—will lead to continued technological change, to substitution of improved capital inputs for labor, and to larger and fewer commercial farms. Technological change brings gradual and somewhat predictable changes in farming to which farms can adjust with minimal difficulty (because most of the adjustment is by farm youth who readily find employment elsewhere). Some operators and their families will be unable to maintain the management skills and the technological pace necessary to compete in a dynamic economic environment. Some farm families who fall behind will be unable to form an economic unit or find satisfactory means of livelihood because of misfortune such as illness, disability, an unexpected turn of weather or prices, and a host of other factors simply labeled bad luck. The public has a role in providing a safety net for such persons. Commodity programs and credit programs alone do not meet the needs of these families.

Farmers facing financial failure typically progress through successive stages of disbelief, anger, and resignation. With time, most say they are better off having made adjustments, and the objective indicators such as income, housing, and access to community services indicate they are better off (Tweeten and Brinkman, 1976, pp. 88-92). But public programs can ease trauma during the difficult adjustment period. With proper assistance, many displaced farmers can find satisfactory jobs outside of agriculture (Mazie and Bluestone 1987, p. 1). Farm families can benefit from several forms of help to make a successful transition to nonfarm jobs:

—*Personal support.* Such support can include counseling, help in assessing their financial condition, and legal and technical information to help them adjust to new circumstances and make decisions in selling their farm assets.

—*Financial bridges.* Displaced farm families need a source of income until they can obtain work in the nonfarm sector.

—*Help to find work.* Skills assessment, classroom and on-the-job training, and job search and relocation assistance can help them find new work.

Most federally funded programs providing such help for displaced workers have been designed for wage earners, not self-employed persons like farmers. Innovative state and local institutions are creating new programs tailored to farmers' special requirements. Because dislocated farmers are often long on skills but short on recognizing them and how they can be used outside of farming, the programs emphasize confidence building, assessing skills and interests,and developing job search skills. Personal and career counseling is included. Some states will reimburse employers for providing on-the-job training for six months. Stipends are not available to those in classroom training, but funds for tuition and books are available for up to one year. Supportive services such as child care, transportation, and counseling are also available.

Reaching displaced farmers is an important element of most of the programs. Organizations linked to the community, such as the Cooperative Extension Service, are often most effective at encouraging farmers to learn about and take advantage of available programs.

The principle of providing assistance under the Trade Adjustment Assistance (TAA) program enacted in 1962 is to assist workers displaced for reasons beyond their control. This criterion is unworkable because it is impossible to judge in most instances whether the circumstances were within or outside of the individual's control. Job displacement in farming occurs because of changes in macroeconomic and trade policy, weather, unfortunate timing of asset purchases, poor management, and a host of other reasons impossible to sort out. It makes sense not to attempt to assess reasons for displacement before providing assistance for displaced farmers. With adequate funding and recognition that training can increase earnings and GNP, training need not be confined to workers dislocated by exports or other reasons beyond their control. In most states it will not be feasible to establish special adjustment programs for displaced farmers. A sustainable program to assist displaced farmers probably needs to be part of a general program serving all workers but with provisions to meet the special needs of farmers.

4. The vocational agriculture program in high school has served youth well over the years, and has been especially important in establishing a sense of pride,

responsibility, citizenship, and leadership. Changes could improve the program, however. The program is costly per student, can unduly encourage students with bleak prospects for farming success to become operators, and can detract from needed training in science, mathematics, foreign languages, and English. The modern day commercial farm requires a high level of business acumen, portfolio-management capabilities, and risk-management skills comparable to those required to run a sizable nonfarm business. Owners and operators of such nonfarm businesses often recognize the great risk and very high level of managerial ability required. A college education, even a Master of Business Administration (MBA) degree, is viewed as extremely useful.

On the other hand, those who would become modern-day commercial farm operators all too often underestimate the requirements to be successful. It is extremely important for prospective operators to be candidly informed of the high level of managerial competence, ability to handle risk, and resource requirements for an efficient, viable commercial farm. Imparting a romantic-nostalgic image of a farm way of life engenders expectations which inevitably will clash with reality, leaving the unprepared operator disillusioned, financially crippled, and prone to turn to taxpayers for maintaining the farming operation. Adequate training, experience, and counseling are essential to minimize unfavorable outcomes.

The current preparation of farm operators and managers could be improved by:

—More intensive training in science, mathematics, English, computers, communication, and other basic skills in high school while minimizing training in vocational courses—the latter reserved for post-high-school programs.

—Strengthened 4-H programs to teach citizenship, responsibility, leadership, and related topics in programs outside the school and reinforced with projects in agriculture and other fields available to youth from all walks of life, including the urban ghetto. Career counseling is an important component allowing students to be realistically apprised of requirements for and consequences of entering agricultural as well as other occupations.

—Strong post-high-school vocational agricultural training programs in area vocational-technical schools. Certificate programs in junior colleges can be strengthened and expanded in numbers. Intensive training would take place in management as well as technical aspects of farming.

—Strengthened programs of training for commercial farm operators in four-year and advanced degree programs in colleges of agriculture. These programs would include not only rigorous training in traditional areas such as animal science, crop and soil science, and agribusiness management, but also in liberal arts, social sciences, humanities, mathematics, and basic science. Some universities currently have such programs, but these can be strengthened. Many new farm operators will not come from a farm background; for them internships are important. In short, the apprenticeship of growing up on a farm and being the son of a farmer is no longer adequate preparation alone for the successful operator and manager of tomorrow's commercial farm in a viable agriculture.

For the foreseeable future, agriculture will be troubled by having too many rather than too few farms and operators. There will be more than enough farm families and farms to provide a competitive economic environment and adequate food and fiber supplies.

5. The real volume of aggregate farm assets and credit for the farming industry is expected to expand very little in coming decades. The farming industry's credit needs will be a small fraction of the nation's credit use, and farmers who can make a case that they are able to service debt will have no difficulty obtaining credit. Diverse private, cooperative, and federal sources of credit ensure competition and fair credit terms offered to farmers willing to shop around.

Excess credit made available to farmers on easy terms in the 1970s helped create excess capacity in farming and exacerbated the financial crisis of the 1980s. Until excess capacity to produce is reduced, the farming industry will be better served by less availability of credit from federal and other sources. However, the cooperative farm credit system must not be allowed to collapse.

Adequate-size, reasonably well-managed farms which account for the majority of farm output will earn rates of return covering credit costs on the average; taxpayers need not subsidize credit to such farms. Unfortunately, most farms either are not of adequate size or are not well managed, hence do not earn rates of return on assets in excess of interest rates even in economic equilibrium. Many if not most such farmers are willing to subsidize their farming operation from off-farm earnings, hence need no credit subsidies. For the remaining farmers who are unable to compete and are unable to subsidize their operation with off-farm earnings, the public will have to decide whether concessional lending paid by taxpayers is appropriate. A decision not to subsidize will not threaten the economic, environmental, or social viability of agriculture.

Special public policies such as subsidized credit or related income supports are not needed now nor in the forseeable future to assist young people to start farming. Subsidized entry only exacerbates the problem of more resources in agriculture than market demand will support and unfairly competes with established farmers for resources and markets. If public funds are set aside to help farmers, an appropriate focus is helping established operators currently experiencing financial stress rather than creating new starts. These operators were blindsided by macroeconomic forces which they could not foresee, control, or protect against. They deserve compassionate treatment to help them through the current financial crisis in farming.

6. Agriculture inevitably will face some instability because it is subject to vagaries of weather and biological processes of nature. But of special concern are the growing man-made sources of variability manifest in inflation and associated cash-flow and real wealth changes; in real interest rate changes and associated real interest expense and real asset value changes; and in exchange rate changes and associated export-import balance changes. Rising oil prices combined with erratic and overly expansionary money and credit expansion worldwide led to high inflation in the late 1970s and to the counter-cyclical world recession in the early 1980s. Large U.S. federal budget deficits in a full-employment economy contributed to high real interest and exchange rates and to financial crisis on U.S. farms and in developing countries (especially in Latin America) in the 1980s. The economic health of U.S. family farms in particular and U.S. agricultural viability in general will be enhanced and personal trauma reduced by sound federal monetary-fiscal policy. High real interest rates discourage long-term investment in conservation to preserve the environment and intermediate-term investment in buffer stocks to reduce economic instability. In short, sound macroeconomic policies contribute to the long-term economic, social, and environmental vitality of agriculture (Tweeten, 1983).

Trade barriers reduce the level and raise the variability of prices in world markets. Long-term viability of agriculture is damaged by export embargoes. The embargo imposed on agricultural exports to the Soviet Union in early 1980 had little short-term impact on U.S. exports because markets were plentiful. But by diminishing our image as a reliable supplier, it encouraged other countries to seek self-sufficiency and to diversify supply sources. The reputation of being an unreliable supplier gradually erodes U.S. farm exports. Negotiating a reduction in current trade barriers and stifling of urges to impose new trade barriers will help to assure long-term viability of agriculture.

An important issue is the appropriate U.S. policy response to widespread foreign government interventions destroying markets and leading some farmers inaccurately to conclude that "Supply and demand don't exist anymore." First, it is important to recognize who is the big loser from market distortions such as the European Economic Community's (EC's) high rigid commodity price supports and variable import levies in the EC. Its consumers and taxpayers lose far more than its producers gain. Meanwhile, the rest of the world gains at the expense of the EC. Consumers in the rest of the world gain more than producers lose, so the net gain is positive. However, exporters such as the United States competing with EC farm exports are worse off—producers lose more than consumers gain. The "second best" policy (the "first best" is worldwide free trade) under such circumstances is not necessarily to subsidize our agriculture. Producers on well-managed, adequate-size farms will, as in the past, earn resource returns comparable to those elsewhere given time for adjustments whether international trade is open or restricted. Although it is unwise to "shoot ourselves in the foot" just because the EC does, an occasional export subsidy "volley" gets attention and can strengthen the U.S. position in negotiations which need to be pursued with diligence. It pays the United States to remove trade barriers even if other nations do not, but a superior strategy is to trade removal of U.S. market distortions for similar action by other nations.

7. A principal economic problem of commercial agriculture has been and will continue to be annual and cyclical instability. An efficient agriculture must change over time. But excessive instability seriously detracts from the long-term viability of agriculture. Although efficient commercial farms have earned favorable returns on the average over the past three decades, economic outcomes even on efficient farms tend to be highly unstable. Risk is not in itself a reason for government intervention in markets—those who risk investments in the futures market or stock exchange receive no subsidy. However, several public policy initiatives can help to deal with instability while producing economic benefits for society.

First science can develop plants, animals, and production practices less subject to the vagaries of nature. Second, negotiations and international influence need to focus on reducing international trade barriers as noted earlier. Free world trade would reduce world agricultural price instability. It would also increase world income which in turn would expand trade.

Third, producers need education and encouragement to make greater use of private risk-shifting strategies including insurance, the futures market, and put-call options. The private trade acting alone may not provide socially optimal stocks, however. A modest public subsidy, say a simple payment per bushel to store grain buffer stocks might suffice. Perennial holdover of massive buffer stocks of grain and other commodities, as in recent years, not only entails excessive carrying costs borne by taxpayers but also chronically depresses farm commodity prices that work against the long-term economic viability of family farms. Reduction of such stocks and excess resources in agriculture is needed to shift agriculture to dependence on markets and away from dependence on precarious, large federal budget outlays.

8. The public is concerned over environmental impacts of modern farming methods and of pesticides, fertilizers, and other chemicals on food quality and safety. The appropriate response by the agricultural community is to search for the truth, report the truth fully insofar as it can be known, and support appropriate private and public actions to promote the general welfare. Current excess capacity provides a large buffer of production capacity so that restrictions on use of pesticides and other chemicals curtailed to protect food and water will not threaten the adequacy of food supplies. In fact, less agricultural output would raise farm income in the short- and intermediate-run.

Farmers have a stake in a safe food and water supply not only for consumers at home and abroad, but also for themselves as consumers of food and water. Although the market can encourage safe food by paying a premium for high quality products, the market alone and producers' good intentions alone are inadequate. Regulatory standards, inspection, and testing under public authority is required in production and marketing to ensure that foods labeled as organically grown or meeting other standards are in fact grown and marketed as labeled.

The United States has the wherewithal to provide a food supply which not only is dependable in the long run but avoids health risks to consumers from adventitious additives or other sources. All Americans deserve the opportunity to obtain abundant, nutritious, and safe food supplies. Full disclosure, access to information, and increased research are essential in resolving issues of food safety. The issue is not just whether food is "safe" (100% safety can not be achieved) but rather whether benefits of potentially hazardous ingredients exceed costs. Some risk, however small, is posed by any food no manner how it is produced, marketed, or prepared.

Acceptable trade-offs between risk and benefit must be determined by consumers and the political process. Risk-benefit analysis, though in a formative stage and still frequently flawed by inadequate data, potentially has much to offer. Careful information gathering, analysis, and dissemination are critical to sound decisions on such matters. If the decision is made to release a substance that entails risks but expected benefits exceed costs, then more attention can be paid to focusing use on groups with less risk, and informing potential users so each can make a personal decision whether benefits exceed risks of use.

9. Farm commodity price and income support programs entailing a cost of $20-30 billion annually are a major expense to taxpayers. Gains to producers are less than costs to consumers and taxpayers, hence national income was estimated to be reduced $4.3 billion to $6.3 billion annually by the Food Security Act of 1985 (Council of Economic Advisors, 1987, p. 159). Long-term operation of an expensive price support program is in the best interests neither of farmers nor society but some features of the program can help secure long-term viability of agriculture.[17]

An example is the conservation provision of the 1985 Food Security Act. *The Conservation Reserve Program* (CRP) will include up to 45 million acres of highly erodible cropland by 1990. The CRP can reduce soil and water loss while contributing to wildlife habitat, recreation, reserve production capacity, and farm income. No more than 25% of the cropland in any one county can be placed under contract, although upon government approval of a formal request from counties

[17] Commodity programs have not stopped the loss of family farms. If the public wishes to preserve today's financial stressed midsize farms, then direct payments or credit assistance targeted to such farms is an appropriate response. Such policies do not destroy ability of adequate-size commercial farmers to compete in global markets. Land-grant extension, research, and education will continue to provide programs and technology helping midsize family farms. Family farmers need such effort to compete with larger commercial farmers realizing greater economies of size in production and marketing and with part-time smaller farms sustaining themselves by off-farm incomes.

the limit can be exceeded if the county is not "adversely impacted." Three other provisions in the 1985 Act—the Sodbuster, Conservation Compliance, and Swampbuster provisions—also relate to conservation and hence to long-term vitality of agriculture.

The *Sodbuster* provision applies to land not considered cropland prior to the 1985 Act. If a farmer breaks sod on that land, he must develop and implement an approved conservation plan that crop year to be eligible for any government price supports, Farmers Home Administration credit programs, or federal crop insurance and disaster payments. The *Swampbuster* provision applies to wetlands. Such wetlands are not eligible for government programs if their conversion to cropland began after enactment of the 1985 Act.

The *Conservation Compliance* provision applies to land considered cropland when the 1985 Act was enacted but which has a high erodibility rating. If the land is cropped, to maintain eligibility for government programs the farmer must have an approved conservation plan by 1990 and the plan must be fully implemented by 1995.

The U.S. Department of Agriculture had accepted 23 million acres in the CRP by late 1987. This was half of the intended goal by 1990 but a small portion of the 80 to 100 million acres eligible for the program.

Although the Food Security Act of 1985 has made significant strides in protecting the environment, selected changes would improve on the Act. The several possible changes or additions to the CRP listed below are designed to build on or augment the attractive multiple long-term benefits of CRP for a viable agriculture. They are options deserving of consideration but would require in-depth analysis (which the Task Force did not have time nor resources to undertake) before implementation.

—Move forward the Conservation Compliance provisions or delay further CRP expansion until conservation compliance becomes operational so the two features can work together. Ineligibility for regular government programs of cropland not following a conservation plan would encourage movement of land into the CRP. Currently, the eligibility of erodible land for regular price support and diversion programs provides stiff competition for cost-effective implementation of the CRP. Combining the "carrot" of CRP with the "stick" of ineligibility for other programs raises cost-effectiveness of government funds used to convert the most erosion prone land to soil conserving uses. This option would bring more highly erodible cropland into the CRP.

—Increase the proportion of land eligible for the CRP in counties with severe erosion problems; at the same time allow grazing and haying of additional CRP land to reduce unfavorable economic impacts on local communities and to lower bid costs to the government. Increasing the size of the CRP would permit reducing regular acreage diversion and paid diversion programs. The potential unfavorable impact on cattle and forage production and prices needs to be considered, however.

—Use *cropland easement* as an alternative to the above option on highly erodible land. The owner could use the land for grazing, haying, wildlife habitat, recreation, or other uses under an approved conservation plan but could not crop the land. The government could obtain cropping rights by purchase or loan arrangements on a bid basis. The easement might be for an indefinite period. In the case of a loan, the owner could repay the loan with interest to regain cropping rights or the government could temporarily remove easement restrictions on cropping during a national emergency. An advantage of the easement would be its attempt at permanent conversion of highly erosive cropland to soil conserving uses while allowing beneficial uses of land that could help to keep local communities economically viable in the long run. The program, operated on a bid basis to reduce government cost, could remain in place while serving multipurpose objectives in the absence of conventional cropland diversion programs.

—Reduce the risk to farmers of putting land in the CRP in the face of possible future inflation by indexing CRP payments to an index of cash rents, to prices received by farmers, or to the Consumer Price Index. Land would be offered to CRP at lower bid prices if protected from risks of inflation.

—Expand the CRP or easements to control use of nonrenewable groundwater supplies for irrigation on a countywide basis. Mining groundwater such as in the Ogallala reservoir is difficult to justify in the face of current excess farm production capacity and possible need for food supplies in the future. Turning off a few scattered pumps in a county does little to halt the decline of groundwater use—nearby wells will continue to deplete the supply. Pumping needs to be halted over a considerable area but dryland cropping could be continued to help rural communities remain viable. Again where grazing and haying are permitted, attention needs to be paid to safeguard the livestock industry from too rapid an expansion of supply.

—CRP could place even greater emphasis on controlling erosion in criteria for acceptance of bids. A premium would be paid to obtain the most erosion-prone cropland in CRP. Holding reserve production capacity, wildlife habitat, and recreational lands would be important but secondary objectives.

10. As concern over natural resource and environmental issues relating to agriculture intensifies, interest in applying environmental control regulations to agriculture also intensifies. Many of the environmental impacts of agriculture affect third party interests outside of agriculture. The traditional voluntary USDA approach to soil and water management may not be acceptable unless a high compliance rate can be demonstrated.

Not all environmental issues affect third parties outside of agriculture. Increasingly, concern about agricultural chemicals directly affects farmers and other chemical users. Applicators may face risks from improper handling and disposal of chemicals. In some areas, farm families who depend upon private wells for drinking water can be exposed to agricultural chemicals through groundwater contamination. Farmers, like consumers, are exposed to residues in foods from pesticides, antibiotics, and other adventitious additives. If farmers are to play a constructive role in protecting their own as well as other environments, they as well as society must be well informed. Improved educational programs are needed for farmers about management practices to reduce the environmental and health risk of chemicals. Continued monitoring of natural resource and environmental trends is necessary so that agriculture and society can make necessary adjustments to conserve and use resources in a sound manner for this and future generations.

11. Some have contended that farm exports should be stopped or taxed to charge for topsoil "exported" with grain or soybeans. Because the international market is highly competitive, the burden of an export tax would not fall on foreign buyers but on American producers whether they have soil erosion problems or not. Most land for producing crops does not pose severe environmental problems. Furthermore, a bushel of corn used for domestic purposes uses just as much topsoil as a bushel for export and each bushel adds as much to the well-being of Americans. So why single out exports? For equity and effectiveness in protecting the environment, it is appropriate to emphasize conservation programs targeted to problem farms and soils rather than to exports.

12. U.S. foreign economic assistance can expand demand for U.S. farm exports while improving the quantity, quality, and stability of food supplies in developing countries. As nations progress economically under appropriate economic assistance, demand expands for meat, a source of high-quality protein. As income rises, prices sometimes rise sharply because of constraints on production.

U.S. technical assistance can play a critical role in overcoming constraints to expansion of livestock including animal disease, pest, and nutrition problems and product marketing, distribution, and storage problems. If problems of inferior production and marketing technology are overcome, livestock production will expand rapidly along with the derived demand for livestock feed from domestic sources and from foreign sources including the United States.

Many nations are committed to self-sufficiency in domestic food production. A more realistic goal is food security, defined as being assured of adequate food supplies from domestic or foreign sources. In many instances importation of some food and feed allows most efficient use of resources and highest living standards. Higher income allows countries to afford imports when local production fails. The appropriate U.S. stance is to build the reputation of being a reliable supplier and to encourage and strengthen use of the International Monetary Fund's cereal facility. The cereal facility addresses the instability problem by assuring less developed countries of financing for import of cereals when domestic crops fail or international prices soar.

U.S. foreign assistance and other policies can encourage broad-based income and employment growth in developing countries. Such policies can do much to increase effective demand in developing countries and can complement rather than conflict with expansion of U.S. farm exports and with the economic vitality of our agriculture (Purcell and Morrison, 1987).

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