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Ecological Impacts
of Federal Conservation and Cropland Reduction Programs




CAST
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Task Force Report

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Cover Photographs

Upper left. Spring landscape of planted native warm-season grasses and forbs suitable for CRP acres, Marshall County, Iowa. Photograph courtesy of Carl Kurtz, St. Anthony, Iowa.

Upper right. Female Dickcissel (*Spiza americana*) perched on common milkweed (*Asclepias syriaca* L.) growing on CRP acres in Adair County, Iowa. Photograph courtesy of Thomas R. Rosburg, Colo, Iowa.

Lower left. Strips of corn and grain used in conservation tillage. Photograph courtesy of USDA, Soil Conservation Service, Washington, D.C.

Lower right. Scotch pine trees (*Pinus sylvestris* L.) planted in thick beach grass for sand stabilization on CRP land. Photograph courtesy of USDA, Soil Conservation Service, Washington, D.C.

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Foreword

In 1985, a coalition of agriculturalists and environmentalists fashioned the Food Security Act, which was established by the U.S. Congress. This act imposed unprecedented requirements and incentives for conservation through several major programs and provisions.

The CAST National Concerns Committee recommended to the Board of Directors that CAST prepare a report addressing the ecological implications of these federal conservation and cropland retirement programs. The topic was approved by the CAST Board of Directors at the July 1987 board meeting.

Nominations for the task force members were received from the representatives of the CAST Board of Directors. Dr. John R. Abernathy, Director of the Texas A&M Research and Extension Center, Lubbock, was selected as the chair. A highly qualified and broad-based task force of 22 scientists was chosen that includes persons with expertise in plant pathology, entomology, forestry, weed science, soil science, pest management, agricultural economics, rural sociology, hydrology, food science, and wildlife biology. Five additional scientists agreed to contribute to certain sections of the report.

Dr. Abernathy proposed an outline and submitted it to the task force prior to the two-day task force meeting held in Kansas City in April 1988. At the meeting, the members reached a consensus on the scope of the report, developed a detailed outline, established a calendar of completion dates for the first and second drafts of the report, and selected subgroups (each with a chair) to be responsible for writing the chapters of the report. The entire task force revised each draft of the report and reviewed the proofs. The CAST Executive and Editorial Review Committees reviewed the final draft. The CAST staff provided only editorial and structural suggestions. The chair and task force are responsible for all scientific content in the report.

On behalf of CAST, we thank the task force members, who gave of their time and talents to prepare this report as a contribution of the scientific community to public understanding. We thank also 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.

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, and to institutional members of CAST. All individual members of CAST receive a summary of the report and may order a copy of the full report. The report may be republished or reproduced in its entirety without permission. If copied in any manner, credit to the authors and CAST would be appreciated.

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Abbreviations

AAA	Agricultural Adjustment Acts
ACP	Agricultural Conservation Program
ACR	Acreage Conservation Reserve
ARP	Acreage Reduction Program
ARS	Agricultural Research Service (USDA)
ASCS	Agricultural Stabilization and Conservation Service (USDA)
CCC	Civilian Conservation Corps
CRP	Conservation Reserve Program
CSRS	Cooperative State Research Service (USDA)
EPIC	Erodibility Productivity Index Calculator Model
ES	Extension Service (USDA)
FmHA	Farmers Home Administration (USDA)
FS	Forest Service (USDA)
FSA	Food Security Act of 1985
HEL	Highly Erodible Lands
PIK	Payment-in-Kind Program
SCS	Soil Conservation Service (USDA)
Soil Bank	Conservation Program of the Soil Bank
USDA	United States Department of Agriculture

Executive Summary

The year 1985 was important for establishment of agricultural policy as a coalition of agriculturalists and environmentalists fashioned the 1985 Food Security Act. This act continued the recent pattern of large economic transfers to farmers, but imposed unprecedented incentives and requirements for conservation. The legislation produced by this new alliance combined many objectives: (1) reduced production of major crops, (2) farm income enhancement, (3) soil conservation, (4) improved water quality, (5) improved fish and wildlife habitat, and (6) enhanced ecological diversity.

Several major conservation programs were established by the U.S. Congress with the 1985 Food Security Act. Major provisions included the Conservation Reserve Program (CRP), Sodbuster, Swampbuster, Conservation Compliance, and the Acreage Reduction Program (ARP). Together, these programs have a goal of reducing crop production in the United States, particularly on soils classified as highly erodible. To date, these conservation and production adjustment programs have targeted some 170 million acres of land. For example, the national goal for the CRP is 40 to 45 million acres, and over 33.9 million acres have been accepted thus far.

The role of this CAST task force was to address ecological implications of the programs, utilizing expertise from disciplines and geographic areas affected by these new provisions. Concern about ecological changes that might be caused by major shifts in crop production is evident in specific areas of the United States. This report reflects some of the major concerns, as well as some of the highly beneficial effects that can be anticipated from such programs.

The beneficial impacts that attracted the interest of conservationists to these programs are primarily soil conservation, improved water quality, increased fish and wildlife habitat, and ecological diversity. Since these programs reduce continuous annually tilled crop production and introduce a degree of environmental diversity, conservationists believe these programs generate current benefits and, at the same time, establish a more sustainable pattern of land use. In addition to environmental benefits, agricultural advantages may accrue if beneficial organisms are encouraged and reliance on pesticides diminished.

However, some agriculturalists are concerned that the CRP and set-aside lands may become islands of infestation, increasing the exposure of surrounding cropland to weeds, insects, plant pathogens, and destructive wildlife. These conflicting views should not be surprising; environmentalists have cautioned against the risks of continuous cropping, while much of the dynamics of modern agricultural technology have been directed toward the "perfection" of production systems with relatively little crop diversity.

The authors considered policy issues at two levels: (1) minor adjustments of the rules and provisions of the 1985 legislation, and (2) substantial changes in programs.

Future legislation should provide for research funding to better understand ecological relationships. Based on such research, improved management practices could be developed and promoted to optimize the benefits from programs such as ARP and CRP. Proper selection of plant species for long-term set-aside programs and use of good management practices are necessary to produce beneficial effects. Long-term set-aside programs such as CRP could help alleviate pest problems associated with short-term programs. Planting of trees on CRP lands should be encouraged for some geographical areas.

More radical changes in land retirement programs may include extending the commitment beyond ten years. Costs may be justified by increased recreational use, improved quality of ground and surface water, and reduced soil erosion. The objectives of the set-aside, CRP, sodbuster, and swampbuster programs are varied and not always in harmony. These conflicts among objectives become policy issues, and policy research is needed to clarify the issues, identify options, and attempt to predict the impacts of alternative courses of action.

Practices used by landowners to control pests on land set aside from production will not be widely adopted unless they are inexpensive, easy to implement, consistent with other practices in use on the farm, require little monitoring and maintenance, and require little investment of time and labor. Innovative research and extension methods will enhance adoption and success of good management programs.

A list of studies needed to determine the short- and long-term effects of the federal conservation cropland reduction programs on weeds, diseases, insects, and wildlife is contained in the full report. The authors stress the need to develop and establish extension educational programs to promote good management practices on land removed from production.

When U.S. land has been used for maximum production, the world food market has sometimes not been very attractive economically. However, the continuing increase in the world population and the chance for a weather disaster that could eliminate or greatly reduce the market surplus could change this situation rapidly. Therefore, the impact of converting land presently enrolled in conservation programs such as ARP and CRP back to full or partial crop production should be determined (Knake, 1983b).

Consideration must be given to all segments of society in development of consistent national policies. Agricultural crop reduction and conservation policies should be consistent, whenever possible, with national environmental policies. Policy inconsistencies and constraints must be identified and reviewed. Policymakers should address technical, social, economic, and environmental problems. Policies should be designed to facilitate improvement of economic and ecological stability in the rural United States, while minimizing detrimental ecological effects.

Introduction

Several major conservation programs were enacted by the U.S. Congress with the 1985 Food and Security Act (FSA). Major provisions included the Conservation Reserve Program (CRP), Sodbuster, Swampbuster, Conservation Compliance, and the Acreage Reduction Program (ARP). Together, these programs have a goal of reducing crop production on U.S. soils classified as highly erodible by wind and water. To date, these conservation programs have targeted some 170 million acres of land in the highly erodible classification.

The role of this task force was to address ecological implications of the programs utilizing expertise from disciplines and geographic areas that are or may be affected by these new provisions. Concern about ecological changes caused by major shifts in crop production is evident in specific areas of the United States. This report will reflect some of the major concerns, as well as some of the very beneficial effects that can be anticipated from such programs. Suggestions are made for developing improved vegetation management for the areas removed from production so the beneficial effects can be further accentuated.

Recommendations also are made especially on the need for additional research and extension activities and interagency cooperation to help optimize beneficial effects and avoid potential negative effects of these programs. Research is needed to develop improved management practices that can be promoted by the Cooperative Extension Service and other agencies. Studies also are needed to monitor the impact of these programs and provide information to policymakers as they consider program modifications for the future.

1. Agricultural Acreage Reduction Programs

Overview

Overproduction in agriculture first became a major problem in the United States in the years following World War I. Farmers produced supplies of food and fiber needed for the war effort, and then found export markets disappearing as the war ended. This pattern was repeated following World War II. With production from nearly one in four acres available for export in recent years (U.S. Department of Agriculture, 1987c), highly volatile world demand is a major factor influencing domestic agricultural production and prices.

Overproduction of U.S. agricultural products also has been due to the tremendous gain in productivity per acre. Between 1930 and 1980, U.S. farm output rose by almost 150% (Harrington and Manchester, 1985). The source of this gain was the development and application of such technological advances as: mechanization, hybrids and improved varieties, chemical fertilizers, pesticides, and irrigation.

To address overproduction by U.S. farmers, the federal government has offered acreage reduction programs for more than 50 years. The primary purposes of these programs have been to reduce the overproduction of agricultural commodities and to elevate the depressed prices of agricultural products and declining farm income.

Previous Acreage Reduction Programs

Acreage reduction traditionally has been implemented with short-term programs to curb surpluses. The first of these was organized under the Agricultural Adjustment Acts (AAA) of 1933 and 1938. Since then, other annual programs have included cropland adjustments, setting land aside from production, acreage reductions, acreage reserves, payments-in-kind (PIK), and cash payments to encourage reduced production. These have all been primarily short-term programs aimed at curbing crop surpluses.

Long-term programs, to limit production of agricultural commodities, have been used as a supplement to annual programs in times when overproduction caused severe and prolonged financial crises for farmers. Long-term programs to encourage the semi-permanent conversion of ecologically fragile farm land to non-crop use have been more effective for controlling soil erosion and improving fish and wildlife habitats than the annual programs.

Several programs have been developed specifically to address conservation, including: the Agricultural Conservation Program (ACP), created in 1936; the Great Plains Conservation Program, which began in 1956; the Conservation Program of the Soil Bank (hereafter referred to as the Soil Bank), established in 1956; and the Conservation Reserve Program (CRP), established under the Food Security Act (FSA) of 1985. The Soil Bank (1956) launched the era of what Ericksen and Collins (1985) have called "modern acreage reduction programs." Previous programs generally restricted production of specified agricultural commodities, but did not require diversion of land to noncrop use. In contrast, under the current CRP, land must be removed from agricultural production for ten years.

The trend in agricultural acreage idled by acreage reduction programs is shown in Figure 1.1. By 1960, the last of five years during which farmers could enter land into the Soil Bank program, 28.7 million acres of former cropland was planted in conservation vegetation. Thereafter, as the three- to five-year contracts for land with grass or grass-legume seedings (ten-year contracts were required for trees) began to expire, acreage in the Soil Bank started to decline, while land idled under annual programs increased rapidly. In combination, these programs idled 64.7 million acres in 1962; a record that was not exceeded until 1983, when 47 million acres were enrolled in the PIK program and 31 million acres were in annual set-aside programs, for a total of 78 million acres.

The total number of acres planted to principal crops (including hay), plus land idled by federal programs, varies little from year to year. Since 1955, the greatest number of cropland production acres was 387 million acres in 1983, and the lowest number of acres was 328 million acres in 1974. The percentage of cropland acres idled by federal programs has ranged from zero in 1955 and in 1980-1981, to 20% in 1983.

Figure 1.1 also shows the U.S. Department of Agriculture's projection of land to be idled by acreage reduction programs through 1992. Land placed in the ten-year CRP is anticipated to reach 45 million acres by 1992.

Programs of the Food Security Act of 1985 (FSA)

The FSA provides for the continuation of both annual and long-term acreage reduction programs. The annual programs are targeted at major commodities, such as wheat, feed grains, upland cotton, and rice. Provisions of the FSA include:

1. Acreage limitations, which are percentage reductions being applied to each farm's base for specified crops. For the first time in a farm bill, base reduction becomes mandatory when stocks are expected to exceed pre-established levels.
2. Set-asides, which are percentage reductions of established (historical per farm) crop plantings that cannot be harvested.
3. Paid diversions, which are payments to farmers for not planting land in historic base acreage crops.

The FSA also provides for multiyear set-aside programs for the major commodity crops, but these are discretionary for the secretary of agriculture and have not been implemented.

As previously mentioned, the 1985 FSA provided for the long-term retirement of cropland under the CRP. In addition, the FSA introduced Sodbuster, Swampbuster, Conservation Compliance, and Farmers Home Administration (FmHA) programs that link farm credit with conservation and environmental concerns. While none of the latter programs are considered acreage reduction programs *per se*, they affect cropland acreage, ecological considerations, and the environment. Thus, they are included in this report.

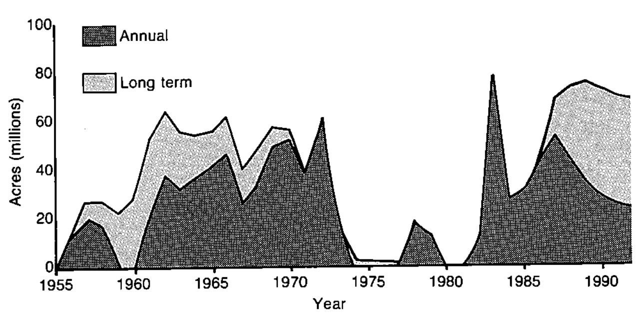

Figure 1.1. Area in acreage reduction programs, 1955-1987, with projection to 1992 (Moulton, 1989).

Acreage Reduction Program (ARP)

The ARP with 20 to 30 million acres has been considered as short-term acreage reduction. The amount of land and specific areas utilized by farmers in ARP varies per annual guidelines. Land may be out of production one to several years and is subject to certain management criteria.

Conservation Reserve Program (CRP)

The CRP is the newest of the long-term acreage reduction programs with a goal of enrolling 40 to 45 million acres. The primary goal of the CRP is to reduce water and wind erosion on the nation's most highly erodible and fragile croplands (U.S. Congress, 1985). Other goals of the program are to:

1. Protect long-term capability to produce food and fiber.
2. Reduce sedimentation.
3. Improve water quality.
4. Create better habitats for fish and wildlife.
5. Curb production of surplus commodities.
6. Provide needed income support for farmers.

The CRP is a voluntary program that places qualifying land into permanent, soil-conserving covers such as grass and trees for a ten-year contract period (payment per acre on a bid basis). Farmers in the program must maintain the conservation cover at their own expense and may not use the land for commercial purposes. However, leasing the land for hunting, fishing, and some other recreational uses is permitted. Under emergency conditions such as drought, some provisions may be made for use of forages for livestock. Changes were made in the program in 1988 to encourage the enrollment of filter (buffer) strips along streams and other waterways and to promote additional tree planting. Cropped wetland acreage was allowed starting with the 8th signup in 1989.

Almost two-thirds (21.7 million acres) of the cropland contracted in the CRP were farm base acres (Table 1.1). Planting these lands into grasses or trees reduced erosion from an average of 20.9 tons of soil per acre per year to 1.6 tons (U.S. Department of Agriculture, ASCS, 1990). If CRP reaches its targeted level of 40 to 45 million acres, it would remove over 10% of the nation's cropland from production and should reduce overall soil erosion by 850 million tons of soil per year.

Farmers began in March 1986 to submit bids for CRP enrollment. Over 33.9 million acres were under contract as of January 1990. Participation has been especially strong in the Great Plains states (Table 1.1).

Table 1.1. Conservation Reserve Acres, January 1990 (U.S. Department of Agriculture, ASCS, 1990)

	Total acres contracted	Tree acres	Filter strip acres	Base acres	Total rental cost (dollars)	Average annual rental ($/acre)	Soil loss before contract (tons/ acre/yr.)	Soil loss after contract (tons/ acre/yr.)	Net erosion reduction (total tons/yr.)
Total	33,922,565	2,179,291	48,829	21,763,479	1,659,809,432	48.93	20.9	1.6	655,632,981
Alabama	519,529	278,475	548	198,930	21,950,200	42.25	19.0	1.2	9,262,162
Alaska	25,375	0	0	16,332	904,419	36.61	5.8	1.0	118,128
Arizona	0	0	0	0	0	0.00	0.0	0.0	0
Arkansas	225,353	125,695	669	120,801	11,045,540	49.01	15.5	1.3	3,214,291
California	183,054	1,409	0	93,846	8,897,457	48.61	15.0	1.4	2,496,189
Colorado	1,953,042	642	20	1,119,255	80,307,507	41.12	27.6	2.9	48,373,834
Connecticut	10	10	0	10	500	50.00	15.0	3.0	120
Delaware	985	173	263	607	65,050	66.09	9.2	1.3	7,805
Florida	123,013	112,067	1	45,966	5,153,526	41.89	16.3	1.1	1,879,683
Georgia	663,156	608,048	1,338	358,412	28,531,375	43.02	13.7	1.1	8,336,660
Hawaii	85	31	0	0	6,800	80.00	5.0	1.0	340
Idaho	791,061	2,472	13	499,223	35,950,494	45.45	17.5	1.6	12,555,336
Illinois	633,580	22,560	3,409	372,120	47,768,036	75.39	21.2	1.1	12,762,181
Indiana	364,729	9,699	2,854	204,303	26,312,352	72.14	17.5	1.3	5,922,233
Iowa	1,970,159	10,927	2,503	1,214,889	159,585,876	81.00	19.7	1.3	36,258,631
Kansas	2,861,785	2,896	939	2,102,380	151,144,532	52.81	18.1	1.8	46,499,899
Kentucky	416,799	3,029	1,251	222,429	24,565,200	58.94	36.1	1.8	14,323,459
Louisiana	132,907	71,446	87	222,429	24,565,200	58.94	13.3	1.2	1,597,500
Maine	37,222	2,538	20	6,288	1,838,581	49.39	8.0	1.0	262,049
Maryland	16,058	1,325	2,261	8,358	1,146,222	71.38	11.0	1.2	158,029
Massachusetts	32	10	1	21	1,520	47.65	8.0	1.1	222
Michigan	196,304	10,424	1,041	107,254	11,558,057	58.88	13.5	1.2	2,400,211
Minnesota	1,830,672	43,001	2,138	1,228,619	101,635,179	55.52	18.1	1.2	30,901,480
Mississippi	726,897	428,115	2,774	250,890	30,792,219	42.36	22.8	1.4	15,574,917
Missouri	1,504,412	10,511	2,299	734,868	94,456,576	62.79	20.1	1.2	28,402,419
Montana	2,720,134	1,222	12	1,761,101	101,963,726	37.48	14.5	1.4	35,553,840
Nebraska	1,348,929	2,944	339	884,893	74,801,132	55.45	24.1	1.7	30,234,603
Nevada	3,124	0	0	839	124,940	40.00	17.1	1.4	49,130
New Hampshire	0	0	0	0	0	0.00	0.0	0.0	0
New Jersey	661	5	0	162	35,360	53.51	18.0	1.8	10,673
New Mexico	480,765	0	0	391,794	18,200,501	37.86	44.5	3.0	19,927,486
New York	54,605	2,797	64	22,427	3,087,941	56.55	14.1	1.2	703,283
North Carolina	137,040	81,413	104	64,097	6,275,303	45.79	18.1	1.5	2,283,534
North Dakota	3,137,199	1,297	388	2,089,408	120,554,937	38.43	15.7	1.2	45,241,802
Ohio	254,129	9,224	1,362	126,359	17,132,919	67.42	13.2	1.0	3,085,198
Oklahoma	1,155,449	1,123	79	927,347	49,085,212	42.48	24.5	1.6	26,495,577
Oregon	517,150	3,192	27	439,209	25,382,915	49.08	12.7	1.6	5,746,346
Pennsylvania	92,464	2,126	87	35,688	5,872,578	63.51	18.2	1.3	1,550,277
Puerto Rico	440	29	0	0	26,340	59.86	36.4	2.7	14,816
Rhode Island	0	0	0	0	0	0.00	0.0	0.0	0
South Carolina	265,514	208,730	6,145	126,970	11,297,007	42.55	14.0	1.0	3,438,000
South Dakota	2,084,557	1,215	681	1,404,472	86,806,624	41.64	11.7	1.3	21,682,770
Tennessee	429,352	27,108	12,324	202,474	22,200,522	51.71	24.1	1.2	9,854,256
Texas	3,921,377	18,323	34	3,159,125	154,958,284	39.52	37.3	2.1	138,072,958
Utah	232,320	0	0	119,770	9,307,941	40.07	18.9	2.5	3,810,420
Vermont	187	0	0	16	9,370	50.00	14.2	1.5	2,371
Virginia	73,938	28,056	680	35,838	3,867,178	52.30	19.2	1.5	1,307,799
Washington	975,320	1,149	44	593,255	48,621,733	49.85	14.9	1.2	13,331,200
West Virginia	610	32	0	251	29,749	48.78	11.5	1.7	6,000
Wisconsin	604,060	43,795	2,030	292,148	40,833,608	67.60	15.2	1.0	8,556,204
Wyoming	257,022	8	0	125,171	9,878,495	38.43	14.5	1.4	3,357,660

Table 1.2. Conservation cover summary by practice, January 1990 (U.S. Department of Agriculture, ASCS, 1990)

Practice	Acres	%	Cost-share (dollars)	Cost/acre[a] (dollars)
CP1 Introduced grasses	19,818,043	58.42	740,958,422	37.39
CP2 Native grasses	8,121,510	23.94	365,093,838	44.95
CP3 Trees	2,012,805	5.92	79,860,581	39.68
CP4 Wildlife plantings	1,946,915	5.74	73,403,865	37.70
CP5 Field windbreaks	6,833	0.02	1,037,265	151.81
CP6 Diversions	83,472	0.24	808,217	9.68
CP7 Structures	38,017	0.11	1,871,487	49.23
CP8 Waterways	14,960	0.04	1,925,047	128.68
CP9 Wildlife ponds	12,285	0.03	1,108,531	90.24
CP10 Already in grass	1,767,440	5.21	42,230	0.02
CP11 Already in trees	84,793	0.25	39,258	0.46
CP12 Wildlife food plots	14,953	0.04	0	0.00
CP13 Filter strips	48,837	0.14	2,290,641	46.90
CP14 Wetland trees	83,299	0.24	4,826,014	57.94
Total	34,054,162[b]		1,273,265,396	

[a] Some of the practices listed are usually applied to areas of less than an acre in size.

[b] Exceeds 33,922,565 acres shown as acres contracted in Table 1.1 because supporting practices such as diversions, structures, and waterways occur on some of the same acres as the vegetative covers. These supporting practices are only authorized for cost-sharing when required to permit establishment of permanent covers by controlling excessive erosion.

Table 1.2 indicates the type of cover on CRP acreage. Grass plantings account for 90% of the program acres. Of new covers, 27.9 million acres are grass, with introduced grasses being favored over native grasses by a ratio of more than 2:1. An additional 1.3 million acres were already in grass under other programs, but these acres had the required cropping history and qualified as cropland under CRP regulations.

Historically, long-term acreage reduction programs have provided major boosts to tree planting, as is evident from the data in Figure 1.2. Tree planting is expected to increase from 2 million acres (6% of CRP) to over 3.5 million acres, as the total enrollment in the reserve grows to 45 million acres (Figure 1.3). Currently, tree planting is a major program component in the southern states, where trees constitute over 90% of the CRP in Florida and Georgia, and about 80% in South Carolina (Table 1.1).

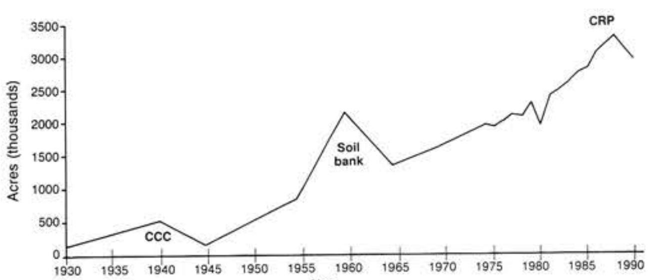

Figure 1.2. Tree planting in the United States, 1930-1989 (Moulton, 1990).

Figure 1.3. Tree planting machines used to plant tree seedlings, such as these Loblolly pine trees (*Pinus taeda* L.), on most agricultural land. Photograph courtesy of Robert J. Moulton, USDA, Forest Service, Washington, D.C.

Sodbuster

Sodbuster provisions of the 1985 FSA apply to highly erodible land not used to produce annual crops during the period 1981 to 1985. Producers who farm this land are denied most farm program benefits unless they have an approved conservation plan. Sodbuster applies to 502 million acres, most of which is currently in native range and forest. About 227 million acres are considered to have potential for conversion to cropland (U.S. Department of Agriculture, 1987a).

Basically, sodbuster is intended to discourage farmers from bringing still more land into crop production, like that currently being enrolled in the CRP. In some instances, farmers may have sodbusted in the past to expand their bases for program crops (Ericksen and Collins, 1985). In the past, federal government crop insurance, disaster payments, and credit have likely favored the production of program crops and have made farming in high risk areas more attractive (Miranowski and Reichelderfer, 1985; Moulton and Dicks, 1987).

Swampbuster

The swampbuster provisions of the FSA are designed to discourage additional conversion of naturally occurring wetlands to production of agricultural commodities. As in the case of sodbuster, the disincentive is the loss of federal farm program benefits. However, unlike sodbuster, those who swampbust cannot maintain eligibility for programs by implementing any type of plan. The Tax Reform Act of 1986 also terminated important tax advantages related to wetland conversions.

In 1982, the United States had about 90 million acres of wetlands (U.S. Department of Agriculture, 1987b), which was about one-half as much as existed at the time of earliest European settlement of the United States (Figure 1.4). Agriculture has been the reason for the loss of most wetlands, and states like Illinois, Iowa, Missouri, and Nebraska have lost more than 90% of their original wetlands. Between the mid-1950s and 1970s alone, 12 million wetland acres were converted to agricultural uses (U.S. Department of Agriculture, 1987b). Losses were especially great in the bottomland hardwood area of the lower Mississippi River system, some wooded areas of North Carolina, and the prairie region of Minnesota.

Of the remaining 90 million acres of wetlands, 65.3 million acres are privately owned and are subject to the swampbuster provisions. As a practical matter, most of the easiest wetland conversions have already been completed, leaving only 5.2 million acres that are considered to have a medium or greater potential for conversion to wetlands.

Conservation Compliance

The conservation compliance provisions of the FSA apply to highly erodible soils on which annual crops were grown at least once during the years 1981 to 1985. To remain eligible for most U.S. Department of Agriculture farm program benefits, farmers must develop and have a locally approved conservation plan for their farms by January 1, 1990. These plans are to be fully implemented by January 1, 1995.

The U.S. Department of Agriculture (1987a) estimates that 118 million acres of cropland are subject to conservation compliance. Farmers are already applying basic conservation practices adequate to meet compliance standards on 35 million of these acres, while over 33.9 million of these acres subject to compliance have been entered in the CRP (Moulton and Dicks, 1987). Barbarika and Dicks (1988) anticipate that conservation compliance will promote increased use of conservation tillage, longer rotations including more forage and cover crops, and other basic practices that can be easily applied to all but 46 million acres with the greatest erosion potential.

Figure 1.4. This scene is an example of a wetland complex in Wisconsin that includes deeper lake habitat as well as shallow wetland habitat. Areas such as this provide shelter and food for a variety of wildlife species including the Tundra swans (*Olor columbianus*) pictured here. Photograph courtesy of Ann Y. Robinson, Decorah, Iowa.

Farmers Home Administration (FmHA) Programs

The FSA granted the secretary of agriculture the option of creating three new FmHA programs addressing natural resource and environmental concerns. The **softwood timber program** is basically a pilot program that allows financially distressed FmHA borrowers to repay their loans with future income from softwood tree plantings on their marginal crop and pasturelands. The **conservation easement program** is intended to assist financially distressed FmHA borrowers by allowing the secretary of agriculture to acquire easements, the value of which would be applied to reduce the amount of the borrower's indebtedness. The softwood timber program generated only a limited response since the passage of the Agricultural Credit Act of 1987, which includes debt write-down provisions for many of the same farmers. Similarly, the conservation easement program has basically been deferred because of these debt write-down provisions.

The third program, **inventory lands**, allows the secretary of agriculture to place restrictive covenants into deeds when federally owned properties in the FmHA inventory are sold to private individuals. These deed restrictions are designed to protect highly erodible and sensitive lands. Also, FmHA may transfer land and interests in land to any Federal or State agency, at no cost, when such land is of marginal value for agriculture, is environmentally sensitive, or has special management value.

2. Ecological Framework

Land-use changes legislated during the 1980s will cause important ecological shifts affecting agricultural production and pest management. Data required to delineate specific changes do not currently exist, but some of the ecological changes that may result from implementation of these land-use programs can be hypothesized.

Several studies have been conducted on abiotic benefits of conservation tillage and conversion of land from crop production to permanent cover (e.g., reduced soil erosion, improved surface water quality, reduced nitrate fertilizer movement into ground and surface waters, and decreased agricultural commodity surpluses). In contrast, the biotic effects of these land-use programs are not well understood. Some changes potentially detrimental to agricultural production may occur. However, with appropriate management, most biological changes could be beneficial to agriculture and the environment. These benefits will result primarily from environmental diversity created by implementation of these new land-retirement programs. Understanding and addressing the biological changes as the new land-management systems are implemented and modified are important if we are to minimize disruption to agricultural production systems.

Possible Effects of Land Retirement Programs

Modern agroecosystems tend to reduce biological diversity within certain plant and animal populations, while long-term land retirement programs that diversify agroecosystems by mixing land planted to trees or grass with cropland will increase biological diversity. Increased biological diversity may come at a price, however, if the trees or grass lands provide habitats for plant and animal pests that invade surrounding cropland. Therefore, it is important to choose plant species that encourage predators of pests and do not harbor less desirable pest species.

The federal land retirement process can cause significant changes in existing agroecosystems, but some of the biological implications of these changes are unknown. Farmers are being asked to diversify their ecosystems without an adequate research base to provide an understanding of the potential beneficial or detrimental consequences.

A commonly held opinion seems to be that weedy plants will initially prevail when land is removed from cultivation, unless appropriate measures are taken to assure their control. The resulting ecology with regard to plant life might be: (1) many small-seeded annual weeds the first and second years, (2) a few perennials the second year, (3) followed by more perennials the third and fourth years, and (4) the gradual establishment of a climax vegetation of a planted desirable species. This sequence of events is generalized, of course, and would vary according to prevailing environmental conditions and management practices.

Dale and associates, in a series of papers (Dale and Gibbons, 1979; Dale 1983a, 1983b; Dale and Smith, 1984), described their efforts to re-establish native prairie on a military park in Arkansas. They found that mixtures of native prairie species such as big bluestem (*Andropogon gerardi* Vit.), side oats grama (*Bouteloua curtipendula* [Michx.] Torr.), switch grass (*Panicum virgatum* L.), little bluestem (*Andropogon scoparius* [Michx.] Nash—Gould), and Indian grass (*Sorghastrum nutans* [L.] Nash), increased from an average of 23% cover after the first year to an average of 81% cover after six years (Figure 2.1). Weedy species declined in direct proportion to the increase of the prairie grasses. Weedy species were less abundant when native prairie grasses were seeded at higher rates. They further noted that successional trends of weedy grasses and forbs during the first years of succession were quite similar to results of other studies in Wisconsin, Tennessee, Illinois, and Ohio. They concluded that "introduction of prairie grasses in the restoration plots has caused successional patterns to be altered by interference or competition sooner than would be expected otherwise" (Dale and Smith, 1984).

The situation is not nearly as clear for other organisms in the same ecosystems. Brosten (1988) cites the concerns of plant pathologists that plant pathogens and vectors of pathogens proliferate in CRP fields. Virus diseases associated with volunteer grains (such as oats, wheat, barley, rye, or CRP grasses) are of particular concern. Mites, leafhoppers, and aphids, which

Figure 2.1. A one-acre prairie restoration plot was established at Pea Ridge National Military Park in Benton County, Arkansas in 1975.

A. Native grass seedlings have attained an average height of approximately 7 cm seven weeks after sowing (July 25, 1975).

B. During the second year, cover of prairie species increased to over 30% by June 15, 1976. Many of the weed species present during 1975 and 1976 were smaller and less numerous the second year.

C. A vigorous stand of prairie grasses (mean cover of 53%) are evident at the same location of the site on September 28, 1977. Indian grass (*Sorghastrum Nutans* [L.] Nash) appeared to be best adapted to the growing conditions in the study area during the first four years, as shown in this picture. Photographs courtesy of Edward E. Dale, Jr., University of Arkansas, Fayetteville.

will feed on both CRP vegetation and nearby crops, are potential vectors of these diseases.

The status of wildlife in monoculture agroecosystems is a major concern of many conservationists. Jahn (1988) maintains that long-term declines in wildlife populations, such as the savannah sparrow, bobolink, dickcissel, and grasshopper sparrow, have occurred in intensely cultivated areas of the Midwest. Also, he cites declines in waterfowl and other wetland species as these marginal lands are drained and converted to agriculture. However, he is optimistic that utilization of conservation tillage and other practices, blended with successful CRP measures, will result in dramatic increases in wildlife on millions of acres. This optimism exists even though past government programs, such as the 1961 Emergency Feed Grain and Wheat Program, the 1983 PIK, and the ARP of the Food Security Act of 1985, possibly had relatively little proven long-term benefit for wildlife (Berner, 1987). These annual set-aside programs may be damaging to wildlife, rather than helpful, if cover crops under these programs are frequently mowed or disked during peak nesting seasons. During the drought of 1988, farmers also were allowed to harvest vegetation on CRP lands, which further disturbed these sites.

The enthusiasm of conservationists, coupled with the growing acceptance by farmers for some of the new practices, bodes well for all concerned. However, we need to understand the long-term biological effects of this new agroecosystem to avoid problems which could alter the potential for desirable ecological diversity.

3. Impact of Federal Conservation and Cropland Reduction Programs on Weeds, Insects, Plant Pathogens, and Wildlife

Conservation Reserve Program, Sodbuster, and Swampbuster

These programs maintain or increase the amount of rural land used as low management habitats that can be exploited by insects, weeds, plant pathogens, and wildlife. The resulting increase in ecological diversity in the new diversified agroecosystems should help provide ecological balance. With appropriate management, these programs should be more beneficial than detrimental for integrated pest management practices and wildlife (Table 3.1, 3.2). The detrimental effects should not be devastating to agriculture in general. However, some insect species, plant pathogens, and weeds, which were previously of minor concern, may become more important by adapting to these habitat changes and inflicting localized crop injury.

Beneficial Effects

A primary benefit of these conservation programs to insect pest management could be to provide alternate hosts for insect predators and parasites which would provide bridges between prey gaps during annual life cycles (Table 3.1). Also, methods could be developed to encourage beneficial insect movement into crops at key times for pest control. Most pests on annual field crops are generalist herbivores, and are not adapted only to specific crop species. Consequently, plants grown on CRP land might serve as alternate hosts at key times of the season to attract potential pest insects away from crop plants.

Diversification of insect habitats in previously simple agroecosystems could benefit insecticide resistance management programs for major pest species. A portion of an insect species population will be isolated in the nonagricultural conservation lands, where insecticides will seldom be used. This unexposed population could then mate with members of the exposed population which may reduce the occurrence or degree of insecticide resistance.

The long-term nature of CRP ecosystems provides an opportunity to use desirable competitive vegetation and other cultural and mechanical weed management practices advantageously, especially for species difficult to control. Farmers have had difficulty controlling some annual grass species in continuous

Table 3.1. Potential beneficial and detrimental effects of Federal Land Management programs on insect pest management in diversified agroecosystems

Program	Beneficial	Detrimental
CRP, sodbuster, swampbuster	Alternate hosts for predators and parasites Catch hosts for pests at key times in the year Reduce incidence of insecticide resistance	Alternate hosts for pests and disease vectors Overwintering or oversummering sites for pests
Conservation compliance	Provide stable habitats for beneficial species Produce poor environments for some pests	Reduce mechanical control of soil inhabitating pests Provide sites for quiescent stages of pests
ARP	Break pest life cycles Cover crops as alternate hosts for beneficials	Volunteer crop and weed species may be pest hosts Cover crops as alternate hosts for pests Increased insecticide use for pests on subsequent crops

Table 3.2. Potential beneficial and detrimental effects of Federal Land Management programs on weed management in diversified agroecosystems

Program	Beneficial	Detrimental
CRP, sodbuster, swampbuster	Annual and perennial populations of agronomic weeds suppressed Less herbicide use	Herbicide drift onto adjacent crops when used Some weeds as hosts for insects, plant pathogens, and nematodes
Conservation compliance	Less soil erosion Less weed movement by machinery Changing weed spectrum with changing cultural practices	New weed control challenges in new cultural systems
ARP	Opportunity to reduce agronomic annual and perennial weeds Less herbicide use	Potential new weed seed production Proliferation of weeds causing intensified herbicide use in future years

corn or sorghum production systems (Knake et al., 1984). Examples include wild proso millet (*Panicum miliaceum* L.), woolly cupgrass (*Eriochloa villosa* [Thunb.] Kunth.), shattercane (*Sorghum bicolor* [L.] Moench.), broadleaf signalgrass (*Brachiaria platyphylla* [Griseb.] Nash), Texas panicum (*Panicum texanum* Buckl.), and foxtails (*Setaria* spp.).

If permanent desirable competitive vegetative cover is established successfully the first year a field is in CRP, nine years or more of little, if any, weed seed production may follow. It is generally thought that annual species fail to establish in the presence of a permanent, dense cover of well adapted perennial species such as smooth bromegrass. Additionally, many seeds will lose viability during the contract period of ten years. The actual seed population that remains will vary with species and environment, but intense weed pressure often associated with certain species will be greatly reduced. In addition to the competitive effect of desirable perennials, allelopathic effects can play a role in controlling annual weeds.

Well established perennial vegetative cover could provide an ideal habitat for beneficial insect or pathogen populations that affect perennial or biennial weed development. Placing land into native grasses for ten years will reduce some soil-borne pathogens that cause injury to economically important plant species. But, additional research is needed to develop the best management practices to take advantage of such phenomena. Herbicide use will probably be minimal on CRP land, because herbicide use would not increase income from the CRP land. However, appropriate selective herbicides may be (and often should be) used to assist in establishing the vegetative cover crop the first year. Some fields may require additional herbicides in subsequent seasons for maintenance. The CRP provides an opportunity to control perennial weeds with herbicides, since application can be made at the most susceptible stages of weed growth without concern for crop injury.

The low level of herbicide use on CRP land will significantly reduce the risks of surface and groundwater contamination, drift, overspray, or runoff of herbicides that could affect adjacent vegetation.

A secondary, but important, aspect of reduced herbicide use in these fields is that the buildup of herbicide-resistant weeds will be delayed or prevented. These specialized biotypes develop most often when either monoculture or short cycle rotations are associated with little if any herbicide "rotation" and with insufficient attention to integrated control programs (i.e., timely pest scouting and use of mechanical control measures) (LeBaron, 1983).

The CRP's long time span and cover requirements make CRP uniquely beneficial for wildlife. Because the CRP is targeted for highly erodible lands, it controls erosion and reduces water pollution more effectively than most previous conservation programs. A recent program rule change allows farmers to enroll filter strips (buffers along waterways, lakes, and wetlands, etc.) in CRP. By trapping fertilizers and pesticides, these strips should enhance water quality and aquatic life (Ribando, 1989).

The program is already starting to provide benefits for many kinds of wildlife, particularly ground nesting birds, such as waterfowl, pheasant, sharp-tailed grouse, quail, prairie chicken, and many songbirds. Increased areas of undisturbed grassland will have a positive effect on the food chain by providing habitats for mammals such as rabbits and rodent species. These species attract the birds of prey that feed on small mammals.

Problems with the CRP undoubtedly will prevent full benefits for wildlife. For example, the most popular cover practices are often the least expensive and easiest to manage, but are also less desirable for wildlife, and more vulnerable during emergencies like the 1988 drought. Short seed supplies of preferred grasses have made grass seed of some species expensive and, in some cases, impossible to purchase during the first year of the program when demand was high. Tree planting and wetland restoration, both allowed as CRP practices, are unpopular in the Midwest, but popular in the Southeast (especially tree plantings).

The primary objective of the sodbuster and swampbuster provisions of the FSA is to discourage bringing environmentally sensitive land into crop production that was not in crop production prior to 1985. Since the primary objective of sodbuster and swampbuster is to maintain *status quo*, the pest control benefits and problems from these programs should be minimal. The impact of keeping sodbuster and swampbuster land out of crop production would be similar to the impacts of CRP. Technically, erosion would be reduced and wildlife habitats would be increased.

Swampbuster has slowed (per EPA research) the disappearance of small, often temporary, wetlands in the nation's prairie pothole region. These wetlands, often termed ephemeral, provide an important habitat for many wildlife species, and a food source for certain migrating waterfowl. Swampbuster allows such areas to stay in production, as long as wetland characteristics are not changed. Swampbuster also has potential to preserve many remaining bottomland hardwood areas in the lower Mississippi River Valley that provide a unique habitat for many types of wildlife, including some endangered species of mammals and birds.

The relationship between loss of birds and loss of bird habitat on farmland is well documented. A recent study in rural Illinois showed that populations of eight grassland bird species declined by 80% or more since 1957 (Graber and Graber, 1983). During the 25-year study period, numbers of Savannah sparrows declined by 98%, bobolinks by 97%, dickcissels and grasshopper sparrows by 96%, upland sandpipers by 92% (Figure 3.1), and two meadowlark species by 84%.

A study of the 1,520-acre Winnebago Research Area in rural northern Iowa estimated that the pheasant population dropped from a high of 950 in 1941 to 28 in 1973; a 40-fold reduction (Basket, 1947; Fischer, 1974). Similar changes in habitat and pheasant populations have been described for Minnesota and Nebraska (Berner, 1987).

The long-term declines in these wildlife populations are caused by several related factors mentioned earlier. Exacerbating these trends have been the negative impacts of mowing set-aside lands compared to the effects of not mowing. For example, local rules for set-aside acreage often require farmers to destroy vegetation at times when undisturbed cover is crucial to ground-nesting bird species.

Figure 3.1. An Upland Sandpiper (*Bartramia longicauda*) returning to a nest containing four eggs in Ringgold County, Iowa. Upland Sandpipers prefer to nest in mid- to tall-grasslands that are undisturbed, such as CRP acres. Photograph courtesy of Thomas R. Rosburg, Colo, Iowa.

Not all wildlife species are affected adversely by such developments; in some areas, white-tailed deer, antelopes, raccoons, rodents, Canada geese, blackbirds, and starlings have increased. Species that are more adaptable to land use changes can become populous enough (in local areas) to become agricultural pests. This happens for a number of reasons — few natural predators are left to control populations, little food is available except in farm fields, and field crops are sometimes preferred over other available foods. It has been found that wildlife food plots, such as those cost-shared by the CRP, can reduce depredation by providing alternative food sources for deer and other wildlife (South Dakota Game, Fish, and Parks Department, 1988).

Detrimental Effects

The concerns of entomologists regarding the new habitats created for insects by the CRP vary across regions of the United States (Table 3.1). In the north central states, entomologists think that the new habitats may produce adults of major soil inhabiting insects, such as wireworms, which lay eggs in croplands. These habitats also could provide mating sites for important Lepidopterous (moth and butterfly) herbivores, such as the European corn borer (*Ostrinia nubilalis* [Hubner]) (Showers et al., 1976).

There is concern in the Northwest that these habitats might be used as alternate hosts by plant pathogens, which could be transmitted to small grains by mites or aphids. A higher incidence of wheat streak mosiac, which is transmitted by the wheat curl mite (*Eriophyes tulipae* [Keifer]), occurred more frequently in wheat fields adjacent to CRP grasses on the Texas High Plains in the spring of 1988 than in fields which were not adjacent to these grasslands. Mites and aphids from such habitats may also transfer the dwarf mosaic virus and other pathogens.

CRP programs are not likely to significantly increase disease infestations from long distance pathogens (e.g., rust species). However, the grass crops will probably provide damaging inoculum of short distance pathogens, such as tan spot, smut, powdery mildew of wheat, *Septoria*, and *Helminthosporium*. These diseases, however, should not be greater under CRP compared to adjacent fields of cultivated cereal crops, since the transmitting insects (e.g., mites) generally favor wheat over other grass species. A major concern should be volunteer small grain in the CRP lands. Grass species that are closely related to wheat (e.g., *Agropyron* spp. or bromegrasses) would be most damaging due to infestation of small grains by root pathogens, such as take-all, foot rot, *Cylindrocladium*, *Rhizoctonia*, and *Pythium*, when land is brought back into production. Most of these pathogens are able to survive in the soil for well over ten years. Whenever possible, CRP land should be planted to a legume (e.g., alfalfa, peas, or lentils) before going to cereal crops because of these soil-borne diseases. Otherwise, removal of grass straw is advisable to avoid the heavy disease inoculum when going out of grass.

Also, CRP acres could serve as alternate hosts for insects to bridge periods when crop hosts are not available. Examples include the Russian wheat aphid (*Diuraphis noxia* [Mordv]), that oversummers on several species of CRP grasses which are recommended in the western United States (Kindler and Springer, 1989) and the boll weevil (*Anthonomus grandis* [Boheman]), that can overwinter in CRP grass residue on the Texas High Plains (Carroll and Rummel, 1989). The CRP fields planted near cropland also may be conducive to grasshopper outbreaks.

Trees planted on CRP land, particularly in the Southeast, could be a source of several important forest insect and disease pests if the trees are not properly managed. A dense, vigorous vegetative cover of desirable species must be established in the first few years of the CRP to ensure that fields have relatively few weeds. Unfortunately, serious weed problems commonly are found in the seeding year, and perhaps the next two to three years. Foresters are also closely observing poor plantation survival on old soybean fields suspected of containing several pathogens and insects (Lantz, 1987). Failure to establish good perennial vegetative cover crops quickly often is the result of: (1) poor seedbed preparation, (2) improper planting dates, (3) little or no weed control, (4) poor quality seed, (5) low seeding rate, (6) little or no fertilization, or (7) lack of timely rainfall. If one or more of these factors occurs, the establishment of the cover may be jeopardized due to excessive weed competition.

Under adverse conditions, the soil reservoir of annual weed seeds may actually increase. This occurred in 1987 in some areas from Texas to North Dakota and west to Washington. Dry weather caused many seedlings on cropland to fail, and consequently kochia (*Kochia scoparia* [L.] Schrad.) and Russian thistle (*Salsola iberica* Sennen & Pau) proliferated. Stricter enforcement of program guidelines and a greater awareness of good management techniques by land managers are needed to help assure adequate weed management.

Regardless of the amount of ground cover by desired species, some perennial and biennial weeds may persist. Even woody species, such as boxelder (*Acer negundo* L.) and blackberries (*Rubus* spp.) may gain a foothold after several years in some areas of the United States. Several perennial weeds that are spread by seeds dispersed in the air may infest adjacent fields. Examples include common milkweed (*Asclepias syriaca* L.), hemp dogbane (*Apocynum cannabinum* L.), dandelion (*Taraxacum officinale* Weber), and several of the common thistles (*Cirsium* spp. and *Sonchus arvensis* L.).

A loss in crop productivity in some fields may occur the first and perhaps second year after a CRP field is returned to crop production. The exact cause of this phenomenon is uncertain, but may be due to nutrient depletion or imbalance, high C:N ratio, allelochemicals, or increased pest problems. However, where some desirable species such as alfalfa have been used on CRP, subsequent crop yields may be enhanced due to such factors as added nitrogen, improved soil physical condition, nutrient availability, and favorable conservation of moisture (E. Knake, D. Worsham, personal communication, 1988).

Plant pathologists are concerned that specific disease problems may be magnified, with such hosts as native grasses and other species that are established on some of the conservation reserve program areas, if not closely monitored. Additional research is needed.

Viruses, such as wheat dwarf mosaic virus, that are found in volunteer wheat and other crops in adjacent lands can be transmitted easily by insects to productive cropland (Ashworth and Futrell, 1961). Certain weed species growing in some of the noncultivated areas also may harbor plant pathogens that could be transmitted by insects or wind to adjoining crops. Measures should be undertaken to control plant pathogens when land is removed from production and native or volunteer grasses are allowed to grow.

Conservation Compliance

This program is different from the others, because it directly affects agricultural ecosystems and integrated pest management programs on land used for crop production. Conservationists predict that this program will increase the acreage that is farmed using reduced tillage concepts and could increase the use of crop rotations. The effects of reduced tillage on insect, weed, and plant pathogen abundance (beneficial and pest species) in crops varies throughout the United States.

Beneficial Effects

Less habitat disturbance and increased cover in reduced tillage fields will favor some beneficial arthropod species, especially those living in plant litter or the soil (e.g., ground beetles, rove beetles, and spiders). The importance of some pests has declined in fields with reduced tillage. Examples include greenbugs (*Schizaphis graminum* [Rond.]) in sorghum planted in wheat stubble, and the lesser cornstalk borer (*Elasnopalpus lignosellus* [Zeller]) in corn (Burton and Krenzer, 1985; Kuhlman and Steffey, 1982).

To meet the regulations of conservation compliance, the use of conservation tillage, zero tillage, reduced tillage, ridge tillage, and crop rotations will become more prevalent. Terraces, diversions, stripcropping, and windbreaks will also be used. These various types of cultural practices may, in some respects, be beneficial in controlling weeds, such as nutsedge (*Cyperus* spp.) and johnsongrass (*Sorghum halepense* [L.] Pers), that are spread by tillage equipment.

Common weed problems, such as redroot pigweed (*Amaranthus retroflexus* L.) may be reduced under reduced tillage systems, because tillage stimulates germination of pigweed seed by exposure to sunlight. Similarly, tillage is conducive to germination or growth of velvetleaf (*Abutilon theophrasti* Medic.).

The main contribution of conservation compliance to wildlife improvement probably will be in the area of water quality, leading to better habitat for fish species and other aquatic animals. However, reducing sediment in already damaged streams or lakes may not result immediately in more fish. Many factors are involved, making the link between reduced erosion and fish populations difficult to pinpoint (Morrison, 1982; McSweeny and Kramer, 1986). However, one can conclude that policies which reduce erosion have great potential to improve aquatic habitat.

Compliance will provide an impetus for more widespread adoption of conservation tillage, which has shown some potential for increasing bird nesting success in small grains and row crops (Rodgers and Wooley, 1983). No-till fields also offer more food and cover than conventionally tilled corn fields.

Detrimental Effects

Because there is less soil disturbance in reduced tillage programs, survival of soil inhabiting insects or those that utilize plant litter is favored. In other cases, not disturbing the crop residue favors quiescent stages in the life cycle of some insects, such as the Hessian fly (*Mayetiola destructor* Say) on wheat. This is also true for several species of soil insects and stalk borers on other crops (Archer et al., 1983; Boring et al., 1987; House et al., 1989).

Conservation tillage includes a range of practices with various descriptive names, such as no-till, mulch-tillage, lo-till, ridge tillage, and strip or contour cropping (Figure 3.2). Maintaining either a minimally disturbed cover crop or plant residues from previous crops on the soil surface reduces soil erosion (Figure 3.3). However, these plant residues that have been of major importance may make weed control more difficult with soil-applied herbicide applications. Fortunately, an increasing array of postemergence herbicides are becoming available (Parochetti, 1981).

The succession of new weed species may require some change in the weed control programs. Plant species such as horseweed (*Conyza canadensis* [L.] Cronq), for example, may rapidly become a major weed problem with reduced tillage.

Increases in perennial weeds and some annual weeds also were identified as serious problems in reduced-tillage systems by Triplett et al. (1983). Potential allelopathic effects on crops were reviewed by Worsham and White (1987). Certain weeds can have an allelopathic effect, but the impact in no-till cropping systems appears to be limited if the residue is left on the soil surface.

Overall, changes in land use have a greater impact on habitat quality than do changes in management

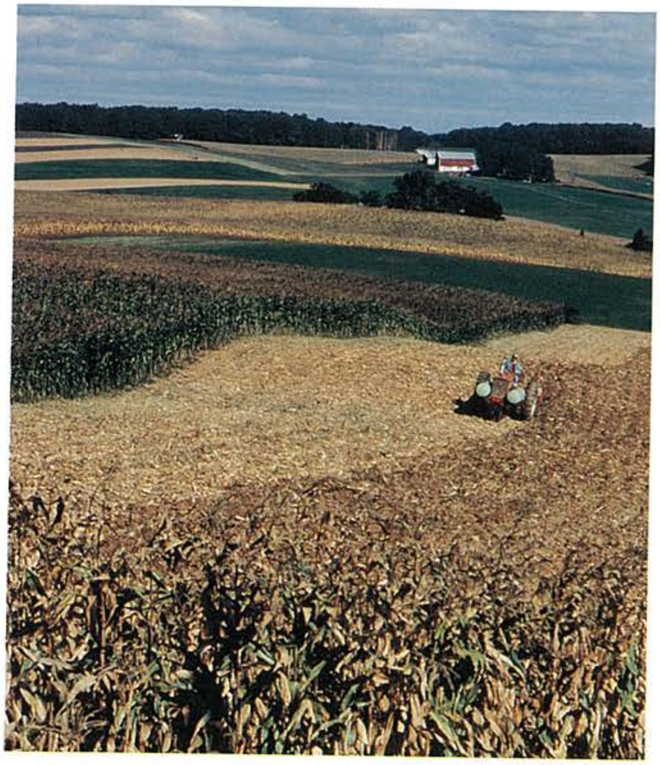

Figure 3.2. Plant residues are being left on a field in Carroll County, Maryland in the fall to help prevent soil erosion. Photograph courtesy of USDA, Soil Conservation Service, Washington, D.C.

Figure 3.3. Cotton planted in a field containing wheat stubble in Terry County, Texas to conserve moisture and soil. Photograph courtesy of John R. Abernathy, Texas A&M Research and Extension Center, Lubbock.

practices. The increased use of herbicides that may sometimes accompany conservation tillage or no-till practices may pose some risks to wildlife (Baker and Laflen, 1983). However, some weed control systems for no-till or lo-till have been developed which do not require more herbicide or higher costs for herbicides (Hartwig, 1990; Knake et al., 1990; Koethe et al., 1989).

Acreage Reduction Program

ARP land is removed from production for one year, but the same area may sometimes be used for ARP for two or more years, depending on current guidelines. This land is often some of the less productive on a farm, or sometimes field borders are set aside to make field operations more convenient.

Beneficial Effects

Initially, many farmers considered this a very temporary program and gave too little attention to good management. But, with the present program in place since 1983, an increasing number of farmers are realizing the benefits of a modest investment in good management of ARP land.

Removing land from production of crops such as corn, and eliminating clean plowing of the land, can break the life cycle of several pests; especially soil insects, such as the corn rootworm (*Diabrotica spp.*) (Kuhlman, 1988). Some cover crops can provide alternate sites for beneficial insects or serve as catch-crops for pests. However, more research on insect relationships for ARP land could help in establishing guidelines to assure appropriate management of insects on ARP.

Various plant species have potential as cover crops on ARP land to help control water and wind erosion, provide wildlife cover, and improve soil physical condition. Legume species can add nitrogen. Several desirable species can help greatly to suppress weed growth by their competitive nature and allelopathic effects (Sommers and Knake, 1983).

Although not allowed in the past, consideration might be given to soybean as a cover crop on annual set-aside lands. Midwest farmers are quite familiar with soybean culture and know how to control weeds well in soybean. Nonharvested soybean can add nitrogen to the soil and, thus, help to conserve energy. In an unfavorable production year, consideration might be given to allowing harvest. Such a program might contribute to supply stability without the problems associated with storage of surplus.

Oats have been the cover crop chosen by many farmers. Under current ASCS guidelines, cover crops on ARP land generally must be destroyed before the dough stage unless the cover is an approved wildlife food plot. Oats were mowed before heading, and weeds like foxtail soon proliferated in the stubble. More recently, farmers were able to obtain a permit to let oats mature. Subsequent disking of the field helps to control weeds present, and working the oat seed into the soil produces a dense mid-summer growth of oats that helps suppress weeds. The oat mulch from such management can be left over winter as a soil cover. The field can then be cultivated in the spring, or soybeans or corn can be planted no-till in the oat mulch.

Sorghum-sudan can rapidly provide dense growth that is competitive with many weeds and the cost of seed is relatively low. However, sorghum-sudan can be a challenge to mow in no-till situations. Also, volunteer sorghum-sudan may appear in next year's crop.

Winter wheat seeded in the spring has been used with success in some areas. Seeding in the spring precludes vernalization of the wheat by the cold of winter so that seed heads are not produced. The wheat can be quite competitive and can also provide allelopathic effects to help suppress weeds. Wheat seed is economical and is less contaminated with weed seeds than oats. However, precautions are necessary in wheat-producing areas to help avoid insect and disease problems that might affect nearby wheat production fields. Other small grains, such as rye and barley, also are suitable cover crops.

More farmers are using legumes, such as alfalfa and clover, as cover on ARP land. Legumes provide good cover to protect the soil from wind and water erosion, help improve soil tilth, and offer wildlife cover. Nitrogen added by legumes reduces production costs for crops, such as corn, that follow and also has implications for resource conservation (Knake, 1983c). Estimates of nitrogen contribution from legumes vary for different species, but can be as high as 80 or more pounds per acre.

Cornbelt farmers are experienced with corn and soybean culture, but some have learned new skills for establishing cover crops. Some have assumed that a "companion crop," such as oats, is appropriate for legumes, and sometimes it may be. However, several new methods can be effective and economical for rapidly establishing a vigorous, competitive cover of legumes with good weed control.

While farmers generally are doing a good job of controlling weeds in cash crops, many hesitate to invest in good weed control on ARP. A greater awareness among farmers is needed to realize the long-term benefits of a modest investment in establishing desirable vegetation and providing good weed control for ARP land (Knake et al., 1988). Since they receive significant government payments for taking land out of production, they should be willing to invest in effective and economical weed control that also benefits subsequent long-term row crop production (Knake 1983a).

The ARP provides an excellent opportunity to control problem weeds such as Canada thistle (*Cirsium arvense* [L.] Scop.), hemp dogbane, Jerusalem artichoke (*Helianthus tuberosus* L.), johnsongrass, and quackgrass. If no crop is present, selectivity is not so critical, and this allows greater flexibility for rates and times of application. Herbicides such as glyphosate, 2,4-D, and dicamba are possibilities. Use of certain herbicides may be more beneficial for wildlife than frequent mowing. However, herbicides should be used judiciously to protect wildlife and reduce potential for contamination of surface and ground water in keeping with resource conservation goals.

Detrimental Effects

The annual set-aside portion of farm programs, in a variety of forms, has been used from time to time to control production of certain farm crops. Relatively lenient guidelines for managing the set-aside acres are frequently detrimental to wildlife, and sometimes may leave the land exposed to wind and water erosion.

Due to the unpredictable nature of the ARP programs, farmers frequently lack reasonable planning horizons necessary for proper management, and often are reluctant to invest in the most desirable vegetative cover practices. A broad framework of rules for managing set-aside acres are made at the federal level, but many details are left to the discretion of state and county ASCS committees.

Poorly managed ARP land is detrimental to integrated pest management programs by providing alternate hosts for insect pest species. Native or volunteer crop plants growing on poorly managed ARP land can be alternate hosts for key agricultural insect pests (e.g., volunteer wheat is an excellent oversummering host for the Russian wheat aphid in the Great Plains and western United States) (Halbert et al., 1989). The use of certain cover crops may provide alternate hosts for insects, some of which can be important pests of subsequent or adjacent crops (e.g., grass cutworms [*Argotis* spp., *Nephelodes* spp., *Feltia* spp., and *Crymodes* spp.] or armyworms [*Pseudaletia* spp. and *Spodoptera* spp.]).

Land retirement programs have been promoted as a means to reduce pesticide use because there will be fewer cultivated acres. However, several entomologists have reported that insecticide usage increased on the remaining cropland as a result of increased soil insect problems and insect vectors migrating from the land retirement program fields (Kuhlman, 1988).

When land is set aside from crop production, significant potential for proliferation of both annual and perennial weeds is created if good management techniques are neglected. If good quality seed is not used for cover crops, seed of new weed species may be introduced to cause significant problems. Wheat and good quality legume seed tend to have fewer weed seeds than oats.

When a crop is not planted, weeds will sprout from the weed seed reservoir of the soil. Annual grass weeds, such as foxtails, are often quite prevalent (giant foxtail [*Setaria faberi* Herrm.] is one of the most abundant) and they frequently suppress broadleaf species. However, annual broadleaf weeds, such as redroot pigweed, common lambsquarters (*Chenopodium album* L.), velvetleaf, Pennsylvania smartweed (*Polygonum pensylvanicum* L.), common cocklebur (*Xanthium strumarium* L.), common ragweed (*Ambrosia artemisiifolia* L.), and common morning glory (*Ipomoea purpurea* [L.] Roth) also can proliferate. Perennial grasses, such as quackgrass and johnsongrass, may become dominant in some fields. Perennial broadleaf weeds, such as leafy spurge (*Euphorbia esula* L.), Russian knapweed (*Centaurea repens* L.), spotted knapweed (*Centaurea maculosa* Lam.), hemp dogbane, common milkweed, field bindweed (*Convolvulus arvensis* L.), and Canada thistle, may intensify, especially without tillage or without herbicide use.

Since no crop for harvest is involved in ARP land, even dense weed stands may not reach an economic threshold during the set-aside period. However, weed proliferation can pose serious problems for future years and significantly increase the probability of exceeding threshold levels in subsequent crops.

Farmers are frequently reluctant to invest time and money for vegetation management on land set aside from production. However, knowledge and technology are available to implement good vegetation management programs on ARP land at a modest cost.

Set-aside acres are sometimes left exposed to wind and water erosion, and unnecessary practices that are detrimental to wildlife, such as midsummer mowings, may be required. Improved management guidelines are urgently needed.

A number of recommendations have been made for improving these programs for wildlife and soil conservation, including:

1. Extend the period a field may be kept in the set-aside program from one year to three or five years.
2. Ban fallowing land without cover.
3. Require ASCS committees to consider wildlife when setting rules for seeding and destruction of annual cover.
4. Require voting representation by natural resource professionals on ASCS committees.

4. Alternatives

Current and Future Policy

The year 1985 was important in agricultural policy, because a new coalition of agriculturalists and environmentalists fashioned a farm bill that continued the recent pattern of large economic transfers to farmers, but imposed unprecedented requirements and incentives for conservation. The legislation produced by this new alliance combines many objectives: (1) reduced production of major crops, (2) farm income enhancement, (3) soil conservation, (4) improved water quality, (5) improved fish and wildlife habitat, and (6) enhanced ecological diversity. Significant income transfers to farmers have been continued. Accomplishment of the other objectives may be more difficult to evaluate.

Land retirement from cropping has been an imperfect technique to control supply, so long as incentives exist to increase crop yields by substituting other inputs for land. The greatest benefit of the environmental and conservation initiatives will be realized long-term, and only with steadfast commitment of the policymakers and with subsequent incentives.

Predicting where the new-found commonality of interest between farmers and conservationists will begin to diverge is easy. Cross-compliance between commodity programs and minimal conservation requirements is still being assessed by many. On the other hand, cross-compliance is a long-held goal among environmentalists. Land retirement programs and programs that discourage conversion of land to cropping (such as sodbuster and swampbuster), always seem to lose their attraction for farmers when commodity prices are high, whereas the major conservation benefits are realized only when land is committed to these purposes long-term.

As a general rule, farmers seek programs that require minimal economic sacrifices and greatest benefits for participation in conservation programs. They like maximum flexibility to receive help from government when commodity prices are low, while profiting in the market when commodity prices are high. Conservationists seek policies that commit farmers to significant conservation practices and programs that are maintained regardless of economic conditions.

The federal farmlands policy should be re-examined with a view to making it serve the legitimate goals with minimal internal inconsistency and at reasonable public expense. The ecological impacts of the CRP, ARP, Sodbuster, Swampbuster, and Conservation Compliance Programs are the primary focus of this report. These programs remove cropland from production, discourage conversion of fragile lands and wetlands to cropland, and promote conservation practices during crop production. Their ecological impacts may be both beneficial and detrimental.

The beneficial impacts that first attracted conservationists to these programs are, primarily, soil conservation, potential for improved water quality, increased fish and wildlife habitat, and ecological diversity. While reducing continuous row crop production and introducing a degree of environmental diversity, conservationists believe these programs generate current use benefits and at the same time establish a more sustainable pattern of land use. In addition to satisfying naturalists and outdoor recreationists, agricultural advantages may occur if beneficial organisms are encouraged and reliance on pesticides is diminished. Some agriculturalists are concerned that CRP and set-aside lands may become islands of infestation, increasing the exposure of surrounding cropland to weeds, insects, plant pathogens, and destructive wildlife. These conflicting views should not be surprising; environmentalists have long been concerned about the risks of continuous cropping, while much of the dynamics of modern agricultural technology was directed toward the "perfection" of production systems with relatively little crop diversity.

These policy issues are considered at two levels: (1) issues that involve relatively minor adjustments of the rules and provisions of the 1985 legislation, and (2) issues that may suggest more substantial changes in programs.

Are Minor Adjustments to the 1985 Legislation Needed?

These issues include adjustments to the rules and guidelines concerning management of CRP and ARP lands. What species are available and should be planted on these lands? What management practices should be encouraged or discouraged, required or prohibited?

The question of CRP and ARP lands as islands of infestation among the cropland has several aspects. If the infestation potential is shown to be significant, crop yields may be reduced, which might tend to reinforce the effectiveness of CRP and ARP as supply control strategies. However, pest infestations from CRP and ARP also may increase pesticide use on cropland, with potential adverse effects on water quality and ecological diversity. Further, a pest infestation may peak during the transition from cropping to more stable ecosystems. Thus, ARP that takes land out of cropping for one or two years may cause greater problems than CRP with its ten-year horizon.

If pest infestations from ARP lands are shown ultimately to be a serious problem, policies to increase the length of commitment to noncropping (i.e., to replace much of the short-term set-aside with longer-term CRP-like arrangements) and to encourage tree planting on CRP land should be considered in some geographic areas. Rules to encourage desirable perennial species on CRP land are preferable to rules that require regular mowing and/or pesticide applications on this land. Further, the conservation and crop management benefits of ARP and CRP are enhanced by establishing more stable ecosystems, such as desirable grasses and legumes, on land taken out of cropping.

In actual practice, many of the plant species such as small grain, clover, alfalfa, and desirable perennial grasses used for ARP or CRP also are grown on cropland and, thus, may not pose a new threat if properly managed. Some native plant species, as well as introduced species, have been established along highways and in public conservation and recreation areas with primarily beneficial effects. The key to avoiding adverse effects is proper selection and use management practices. Future legislation should provide for research funding to better understand some of the ecological relationships. Based on such research, improved management practices should be developed and promoted to optimize the benefits from programs such as ARP and CRP.

What About More Radical Changes in the Land Retirement Programs?

The CRP is clearly directed to control commodity supplies, conserve soil, and improve water quality. Nevertheless, potential conflicts exist among the supply control and environmental objectives. Taking the most productive land out of crops maximizes supply control, but not necessarily the efficiency of production. On the other hand, water quality is improved by reducing run-off, sediment accumulation, and chemical contamination of water on lands that are both fragile and in close proximity to down-stream water supplies or up-stream from concentrations of human populations. Environmental benefits are increased when more people need them.

To further complicate the picture, the income enhancement objective often is interpreted to include a preference for widely distributed benefits. This, of course, is an argument for making CRP attractive to a wide range of farmers, while a policy aimed at maximizing the water quality benefits would imply narrower targeting and a conscious policy of accepting higher bids for land where the water quality benefits of CRP will be the greatest.

The fish and wildlife enhancement and ecological diversity objectives bring additional concerns into an already complicated picture. The mosaic cropping patterns introduced by the present CRP program encourage pheasants, cottontail rabbits, and a variety of songbirds that prefer grassland and meadow environments. Quite different ecological communities may be preferred by some outdoor recreationists. This may include modified CRP of larger contiguous parcels of land planted to trees or allowed to pass through a natural progression to a more diverse ecosystem, including trees and woody perennials.

A policy to maximize the fish, wildlife, and ecological diversity benefits may require a considerable departure from the current CRP. For example, such a program may involve changes to extend the time commitment beyond ten years.

Such modification would reduce the flexibility of farmers to resume cultivation if and when grain prices recover, and would cause concern among local business people in many areas where a modified CRP would seem likely to convert large contiguous sections of cropland to permanent nonfarming uses. However, increased recreational activity, improved quality of ground and surface water, and reduced soil erosion may partially offset such economic losses.

Some individuals desire to create future policies which encourage diversion of acres currently in the base acreage of commodities under federal programs into production of alternative crops. This policy modification could cause major changes in the agroecosystem which deserves significant attention. Although this report does not address the effects of such a policy change, assessment is needed to properly determine the benefits and detriments associated with such a change.

In summary, the set-aside, CRP, sodbuster, and swampbuster programs are aimed at a wide variety of objectives, and that helps explain their political viability. However, these objectives are not always in harmony, and one can readily predict where the interests of various groups within the farmer-conservationist coalition will begin to diverge. These conflicts among objectives become policy issues, and it is the job of policy research to clarify the issues, identify options, and attempt to predict the impacts of alternative courses of action.

Social and Economic Barriers to the Adoption of Pest Management Practices

If research and experience indicate that diversion of farm land due to the Conservation Title of the FSA creates a significant environmental problem in the form of infestation of insect and other pests, mechanisms would be needed to resolve the problem. Given the knowledge base and technologies available to agricultural scientists in the United States, it is highly likely that solutions could be developed for any pest problem created by large-scale land diversion programs. However, it must be recognized that the identification of problems and the creation of solutions are not guarantees that pest problems will be resolved.

The most critical issue associated with the control of insect and other plant pests on the CRP set-aside land is the behavior of land owners. The development of new technologies or new control practices is futile unless land owners adopt and use them. Research focused on the adoption of soil erosion control practices has demonstrated that motivating farmers to adopt recommended conservation practices often is more difficult than developing them (Lovejoy and Napier, 1986; Napier, 1987; Napier et al., 1984).

Some options for controlling insect and other plant pests on CRP land will require changes in the management practices of the farm operator. Changes in management practices will generate costs of some type which will affect the willingness of land owners to adopt appropriate control measures. If the perceived costs of adopting recommended practices are higher than the perceived benefits to the individual farmer, then the practices probably will not be adopted, regardless of the environmental benefits which may be derived from widespread use. Some of the factors which farmers use in the decision-making process about adoption of new management practices are as follows: (1) economic costs of adoption, (2) investment in new knowledge to effectively use new practices, (3) savings in time and labor, (4) the degree of similarity with practices in use, (5) the complexity of the recommended practice, and (6) the level of risk associated with adopting new practices (Rogers, 1983).

One of the most significant factors affecting adoption of new practices is the economic cost of implementation. This will be especially important in terms of pest management on CRP land. Land owners enter into contractual agreements with the Federal Government at a fixed rental fee for a period of ten years. While provisions regarding cost-sharing for initial establishment of cover crops on CRP land exist, provisions for long-term control of potential pests on the retired land are not included. This means that individual land owners must internalize the costs of implementing pest control programs. Unless rental fees are increased or some other provision is made, it is doubtful that many farmers will be motivated to invest much in pest control efforts on CRP and ARP land.

Research focused on volunteer adoption of soil erosion control practices has demonstrated that farmers are reluctant to adopt conservation practices unless economic incentives provided by the Federal Government are used as inducements (Napier and Forster, 1982). One of the reasons that many land owners are unwilling to voluntarily adopt soil conservation practices is that such investments may not generate visible economic benefits in the short-run or long-run (Ervin and Washburn, 1981; Lovejoy and Parent, 1981; Mueller et al., 1985; Swanson et al., 1986). If these findings are generalizable to the adoption of pest management practices on CRP land, then most land owners are unlikely to adopt pest control programs unless the economic costs of implementing the new practices are small. If control of pests on CRP land can be shown to be beneficial to the individual farmer in the short-run, then farmers may consider investing in pest control measures.

Provisions in CRP agreements which require control of noxious weeds is some inducement for control, if county ASCS personnel adequately inspect fields and enforce the provisions. However, such provisions may not include significant weeds not classified as noxious or other pests.

Many of the costs and benefits which are important in the adoption process are noneconomic in nature. Investments in new knowledge and time required to effectively use new management practices become important considerations regarding adoption of new practices. If land owners are required to learn new techniques to control pests or are required to spend considerable time monitoring CRP set-aside lands to apply pesticides at the appropriate time, then the probability is greatly reduced that they will become involved in pest management programs. This is especially true for older farmers who have retired and are renting their land to tenant operators. Such individuals may not be physically able to do the monitoring and may not be able to afford hiring commercial firms to scout or apply appropriate chemicals.

If the recommended practices to reduce pest infestations are consistent with existing management practices, then farmers will consider adopting the recommended practices. This means that methods developed to control insect and plant pests on CRP land must not deviate extensively from existing farm practices. Consideration also must be given to the available technologies. Expecting land owners to invest in new technologies to control insect and plant pests is unrealistic unless the economic viability of the farm enterprise is significantly threatened.

Creation of solutions to pest control without regard to the social and economic constraints to adoption are probably doomed. Unless the solutions offered to land owners are inexpensive, easy to implement, require little monitoring and maintenance, are consistent with other practices in use on the farm, and require little investment of time and labor, they will not likely be widely adopted. If these constraints to adoption are considered as pest management programs are developed, then the probability will be increased that the solutions will be implemented at the farm level.

Recommendations for Research and Extension

Although a wealth of information and experience exists in federal, state, private, and industry research, development, and extension programs of the United States, much additional work needs to be done. The following section details some of the important issues for research and extension needs.

Studies Are Needed to Determine the Short- and Long-Term Effects of the Federal Conservation and Cropland Reduction Programs on Weeds, Diseases, Insects, and Wildlife

Determining the Impact on Weed Populations

The impact of the federal conservation and cropland reduction programs on populations of weeds and other pests undoubtedly will vary by climate, soil type, native and introduced vegetation type, and topography. Initially, annual weed species can deter the establishment of desired species planted for conservation programs. Later, perennial plants may become problems, which will only be partially managed by program mandates for control of vegetation on program land. Undesirable perennial weeds may increase in number and, if unchecked, could spread to adjacent farm land. Additional research is needed to:

1. Determine the effect of conservation and cropland reduction programs on development of weeds in the involved acreage and on their spread to adjacent areas of crop production.
2. Determine the best weed management programs (including herbicides and biological controls) to enhance establishment of conservation planting by plant species and region. Initial attention should be given to annual weeds, particularly during the first two years of grass or tree establishment on CRP acres.
3. Develop the best management program to maintain conservation plantings in a relatively weed-free condition after establishment of perennial grass and legume cover. Maintenance programs should focus primarily on control or suppression of perennial weed species, including use of biological control methods.
4. Determine by region: the interaction of annual and perennial weed plant populations on insects, diseases, nematodes, rodents, and wildlife in conservation plantings; the weed abundance that can be tolerated during establishment and maintenance of conservation plantings; and the impact of weeds on development of insects, plant diseases, nematodes, and wildlife populations.
5. Determine what cover crops or other plant species will most effectively compete and provide allelopathic effects for controlling weeds.
6. Conduct weed biology/ecology research necessary to better understand how to control weed species.
7. Monitor the population of viable weed seeds in the soil.
8. Document the productivity of crops when CRP land is returned to production.
9. Develop models to describe the environmental impact of various vegetation management systems utilized on land following cropland retirement programs.

Determining the Effect of the New Agroecosystems on Plant Pathogen, Nematode, Rodent, and Insect Populations

Plant pathogen and insect problems on crops will undoubtedly change as agroecosystems are diversified. Of particular interest to farmers are the croplands adjacent to program acreages. These lands likely will be vulnerable to insect and plant pathogen movement from program land. Additional research is needed to:

1. Determine the buildup and/or decline of plant pathogens and their vectors, as well as insects which could affect crop-production adjacent to and within conservation and cropland reduction areas.
2. Determine management programs (including rotation, crop selection, and fungicide and insecticide use) to inhibit plant pathogen and insect transfer and buildup in croplands adjacent to and within land conservation and cropland reduction areas.
3. Determine the most desirable plant species that will encourage beneficial predators and other desirable biological organisms, and discourage undesirable insects, plant pathogens, nematodes, and rodents.

Delineating the Influence of Land Use Diversification on Water Quality, Soil Stability, and Biological Diversity

The various biological and physical interactions that take place as the result of integration of the land use programs into existing agroecosystems are not quantified, and are not completely predictable. Implementation of the FSA brings the following excellent opportunity to close significant gaps in current knowledge:

1. Determine the effects of implementation of conservation and other land reduction programs on surface and ground water quality.
2. Quantify sedimentation rates in ponds, lakes, streams, and rivers, as influenced by soil conservation measures resulting from land use diversification.
3. Quantify soil stabilization and soil structural changes, brought about by federal land programs.
4. Determine the biological shifts and diversification of above- and below-ground plant and animal life, resulting from federal land programs.

Determining the Effects of Land Management Programs on Wildlife

Theoretically, current conservation programs should be highly beneficial to wildlife, but the effects need to be quantified. At the same time, an increase inabundance of some species of wildlife could result in undesirable effects on crops grown adjacent to program land. Failure to prevent intolerable damage to crop production by wildlife could be detrimental to land management programs. Additional research is necessary to:

1. Identify and document population changes in wildlife species in conservation cropland reduction program areas.
2. Assess the effect of wildlife population changes on croplands and inhabited areas adjacent to conservation and cropland reduction areas.
3. Identify and develop means for accommodating increases of certain potentially problem species with minimal damage and loss to crop production and to inhabited areas adjacent to conservation and cropland reduction areas.
4. Develop programs that compensate for increased wildlife-induced losses in cropland adjacent to program land.
5. Determine value of program lands for hunting, fishing, and other recreational use.

Establishing Extension Educational Programs to Promote Good Management Practices on Land Removed from Production

While the transition to conservation practices on fragile cropland was accomplished very expediently, it is evident that the short- and long-term ecological implications of these changes in agroecosystems are unknown or not thoroughly understood by many ecologists, farmers, land owners, policymakers, and individuals associated with agriculture. As a result, less than the desired number of acres have gone into the program. Further, significant weed and insect numbers have developed in certain regions causing conservation plantings to fail. A significant spread of undesirable species has often occurred to cause negative effects on crop production and intensified use of pesticides on current and subsequent crops.

A concerted action is required by Cooperative Extension Service personnel, working in close cooperation with other appropriate federal and state agencies, and the agricultural industry to:

1. Disseminate information on program advantages, benefits, and possible disadvantages to assure an orderly transition to diverse agroecosystems. This would provide information beyond that presently furnished by ASCS to provide management tactics based on research findings to maintain the ecological integrity of these diverse agroecosystems.
2. Demonstrate the consequences of implementing land management programs on changing plant, insect, and wildlife ecologies, and identify methods to manage problems which can occur.
3. Identify constraints to adoption of best management practices under the land management programs and determine ways to alleviate these constraints.
4. Design effective programs to monitor the successes and failures of policies and programs. The successes should be analyzed to determine the role of participants in projecting the outcomes, and the failures must be analyzed to determine why the program objectives were not met.
5. Assess the benefits and consequences of returning land to agricultural production upon expiration of the programs.

Evaluating the Consequences of Converting Land Formerly in Conservation Programs Back to Crop Production

Historically, over-production of food and other agricultural products in the United States has been a temporary situation. Presently, the world food market is not economically attractive, but the continuing increase in the world population and the chance for a weather disaster that would eliminate or greatly reduce the market surplus could change this situation rapidly. Therefore, it is prudent to determine the impact of converting land presently enrolled in conservation programs such as CRP back to full or partial crop production (Knake, 1983b). Additional research effort is needed to:

1. Determine effective, economical, and environmentally sound programs for bringing conservation cropland reduction areas back into production.
2. Investigate methods for bringing land back into production that result in tolerable negative effects on soil erosion, sedimentation, water quality, crop pests, desirable biological organisms, and wildlife in general.
3. Develop criteria and procedures for the establishment of the conservation programs such as CRP once the appropriate level of surplus has been attained.

Consideration must be given to all segments of society in development of consistent national policies. Agricultural crop reduction and conservation policies should be consistent, whenever possible, with national environmental policies. Policy inconsistencies and constraints should be identified and reviewed. Policymakers should address technical, social, economic, and environmental problems. Policies should be designed to facilitate improvement of economic and ecological stability in the rural United States, while minimizing detrimental ecological effects. Innovative research and extension methods will enhance adoption and success of programs.

There is also a need to:

1. Establish better institutional mechanisms to assure availability of factual information to legislators and other policy decision makers.
2. Fully assess the effect that major policy changes which require modifications in cropping practices will have on social, economic, and environmental concerns.
3. Determine the transitional effects of major policy changes on existing technology.
4. Establish research and educational components to assure better success in the implementation of policy.

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Appendix 1: Common and Scientific Names of Plant and Insect Species

Plants

Big bluestem - *Andropogon gerardi* Vit.
Bindweed (field) - *Convolvulus arvensis* L.
Blackberry spp. - *Rubus* spp.
Boxelder - *Acer negundo* L.
Broadleaf signalgrass - *Brachiaria platyphylla* (Griseb.) Nash
Canada thistle - *Cirsium arvense* (L.) Scop.
Cocklebur - *Xanthium strumarium* L.
Dandelion (gray-seeded) - *Taraxacum officinale* Weber
Foxtail (giant) - *Setaria faberii* Herrm.
Foxtail spp. - *Setaria* spp.
Hemp dogbane - *Apocynum cannabinum* L.
Horseweed - *Conyza canadensis* (L.) Cronq
Indian grass - *Sorghastrum nutans* (L.) Nash
Jerusalem artichoke - *Helianthus tuberosus* L.
Johnsongrass - *Sorghum halepense* (L.) Pers.
Knapweed (Russian) - *Centaurea repens* L.
Knapweed (spotted) - *Centaurea maculosa* Lam.
Kochia - *Kochia scoparia* (L.) Schrad.
Lambsquarters (common) - *Chenopodium album* L.
Little bluestem - *Andropogon scoparium* (Michx.) Nash—Gould
Milkweed (common) - *Asclepias syriaca* L.
Morning glory (common) - *Ipomoea purpurea* (L.) Roth
Nutsedge - *Cyperus* spp.
Pigweed (redroot) - *Amaranthus retroflexus* L.
Quackgrass - *Agropyron repens* (L.) Beauv.
Ragweed - *Ambrosia* spp.
Shattercane - *Sorghum bicolor* (L.) Moench.
Side oats grama - *Bouteloua curtipendula* (Michx.) Torr.
Smartweed (Pennsylvania) - *Polygonum pensylvanicum* L.
Spurge (leafy) - *Euphorbia esula* L.
Switch grass - *Panicum virgatum* L.
Texas panicum - *Panicum texanum* Buckl.
Thistle (Russian) - *Salsola kali* var. *tenuifolia* Mey.—Fernald
Velvetleaf - *Abutilon theophrasti* Medic.
Wild proso millet - *Panicum miliaceum* L.
Woolly cupgrass - *Eriochloa villosa* (Thunb.) Kunth.

Insects

Armyworm - *Pseudaletia* spp., *Spodoptera* spp.
Boll weevil - *Anthonomus grandis* (Boheman)
Corn rootworm - *Diabrotica* spp.
Cornstalk borer (lesser) - *Elasnopalpus lignosellus* (Zeller)
European corn borer - *Ostrinia nubilalis* (Hubner)
Grass cutworm - *Agrotis* spp., *Nephelodes* spp., *Feltia* spp., *Crynodes* spp.
Grasshopper - Acrididae family, many subfamilies
Greenbug - *Schizaphis graminum* (Rond.)
Hessian fly - *Mayetiola destructor* (Say)
Russian wheat aphid - *Diuraphis noxia* (Mordv)
Wheat curl mite - *Eriophyes tulipae* (Keifer)
Wireworm - *Melanotus* spp., *Aeolus* spp., *Conoderus* spp., and *Ludius* spp.

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