United States
Department of
Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 627

Natural Resources and Users Benefit from the Conservation Reserve Program

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Natural Resources and Users Benefit from the Conservation Reserve Program. By Marc O. Ribaudo, Daniel Colacicco, Linda L. Langner, Steven Piper, and Glenn D. Schaible. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 627.

Abstract

The Conservation Reserve Program (CRP) may generate \$6-\$14 billion (present value) in benefits to natural resources if 45 million acres of highly erodible or environmentally sensitive cropland are removed from agricultural production by 1990. Protecting the soil by retiring and planting permanent grasses and trees on such land for 10 years will improve soil productivity, water quality, air quality, wildlife habitat, and groundwater supply. But the magnitude and distribution of benefits can be altered by changing the emphasis of the program. This report estimates how retiring cropland benefits natural resources under three scenarios of CRP enrollment.

Keywords: Conservation Reserve Program, land retirement program, natural resources, erosion, soil productivity, water quality, air quality, wildlife habitat, groundwater supply

1301 New York Avenue, NW.
Washington, DC 20005-4788

January 1990

Contents

The CRP Has Large Economic Benefits to Farmers and Other Water Users

The level of agricultural production is linked to the quality of natural resources. The CRP removes highly erodible land from crop production and places it into a soil-conserving reserve. This not only slows the productivity-lowering effects of soil erosion but also helps improve the quality of air, water, and soil, and helps maintain diminishing wildlife habitats and groundwater supplies.

The Conservation Reserve Program (CRP), a land-retirement program designed to remove 40-45 million acres of highly erodible cropland from production, may generate an estimated $6-$14 billion (present value) in benefits to natural resources. (Eligibility requirements have changed over the course of the program to include environmentally sensitive land that was not necessarily highly erodible.) Potential benefits include increased soil productivity and groundwater supplies and improved water quality, air quality, and wildlife habitats. We estimated such benefits with procedures that accounted for the physical, chemical, biological, and economic links between agricultural production and the quality of natural resources.

The magnitude and distribution of benefits to natural resources could be altered by emphasizing different goals for the CRP. At the time of this analysis, about 23 million acres of cropland had been enrolled in the CRP. We developed three scenarios of enrolling the additional 22 million acres to complete the program at 45 million acres. The baseline scenario assumed that the pattern of enrolling the first 23 million acres would continue. The forestry scenario assumed that CRP enrollment would be redirected toward areas where trees would likely be planted on the retired cropland. The environmental scenario assumed that the CRP would be redirected toward areas sensitive to threats of environmental degradation. Benefits for the baseline scenario ranged between $6 billion and $13.6 billion. Benefits for the forestry scenario ranged between $7.2 billion and $15.7 billion. Benefits for the environmental scenario ranged between $6.8 and $14.9 billion.

Benefits to natural resources vary widely among regions when different patterns of enrollment are examined. For example, the Lake States realize the greatest benefits in the baseline and forestry scenarios, while the Corn Belt shows the greatest benefits in the environmental scenario.

Regional benefits vary from the baseline scenario when altering the CRP to emphasize forestry or environmental goals. Benefits in the Appalachian, Delta, Lake States, and Southeast regions are higher for the forestry scenario but benefits decrease in the other regions under forestry enrollment. Shifting to the environmental scenario would increase benefits in the Corn Belt, Delta, and Northeast.

Per-acre benefits varied widely among regions and among scenarios, reflecting differences in the severity of erosion, the types of erosion, and the demand for the services that natural resources provide. Demands on natural resources are especially important in generating high benefits per acre. The Northeast and Lake States showed the highest per-acre benefits in all enrollment scenarios. These regions are characterized by high population and large concentrations of industry, which place high demands on water, wildlife, and other natural resources for recreation, municipal, and industrial uses. The Northern Plains and Mountain regions showed the lowest demand for resources and the lowest per-acre benefits. Shifting enrollment from regions with low benefits per acre to those with higher benefits per acre would raise total benefits.

Structure of the Analysis

1. Assume enrollment moves from 23 million acres (1987) to 45 million acres in the future (1990)

2. Develop three scenarios for the pattern of this increase:

   - Baseline (same pattern as through 1987 continues)
   - Forestry (redirect to areas where trees tend to be planted on land removed from crop production)
   - Environmental (redirect to land in especially environmentally sensitive areas)

3. Estimate regional economic benefits from changes in:

   - Soil productivity
   - Water quality
   - Air quality
   - Wildlife habitat
   - Groundwater quality

The Conservation Reserve Program Was Established as a Land Preserve

Some agricultural production practices can harm natural resources. The 1985 Food Security Act authorized a Conservation Reserve Program (CRP) for long-term land retirement to help protect the Nation's resources.

Production of the Nation's food and fiber has wide-ranging effects on natural resources, including soil, air, wildlife, surface water, and groundwater. For example, some cropping practices leave the soil bare for extended periods of time, making the soil more susceptible to wind and water erosion. Soil erosion reduces the productivity of cropland, especially on highly erodible and shallow soils. Wind-borne soil particles can cause property and health damage downwind from the source. Water erosion carries residuals such as fertilizers and pesticides into waterways, possibly imposing costs on water users and harming wildlife. Converting grassland and remnant habitats such as hedgerows, woodlots, and wetlands into cropland can harm wildlife by eliminating nesting sites, food sources, and escape/cover areas. Irrigated agriculture can remove water from aquifers faster than it is replaced, increasng pumping lifts and decreasing water available for wildlife and for future agricultural and nonagricultural users.

Title XII of the 1985 Food Security Act authorized the CRP to protect the Nation's most highly erodible and fragile cropland *(36)*.[1] The CRP is a long-term land retirement program designed to help owners and operators of highly erodible cropland conserve and improve soil and water resources on their farms and ranches. The goal of the CRP is to remove from production 40-45 million acres of highly erodible cropland by 1990, placing that land into uses that conserve the soil, such as planting trees or grasses, for a contract period of 10 years. (At the time of this analysis, 23 million acres had been enrolled.) Participating operators receive half the cost of establishing permanent cover crops and yearly rental payments over the contract period to offset income lost from not producing crops on the enrolled land.

The CRP Helps Preserve Natural Resources

The CRP was established with the multiple goals of (1) reducing erosion, (2) protecting soil productivity, (3) reducing sedimentation, (4) improving water quality, (5) improving fish and wildlife habitat, (6) curbing production of surplus commodities, and (7) providing income support for farmers. The first five goals directly affect the quality of air, water, soil, and wildlife habitats. The CRP meets these goals by removing highly erodible cropland from production. The program was also established with a provision permitting the Secretary of Agriculture to include lands that are not highly erodible but pose an environmental threat.

The CRP requires participating farmers to plant permanent (perennial) vegetation on the enrolled land. The CRP establishes and maintains better soil cover and wildlife habitat than under annual acreage reduction programs because the cover is less likely to be disturbed under the longer CRP contracts.

The CRP Benefits the Environment

The CRP has the potential to generate notable benefits to the environment and to natural resources. Removing 45 million acres of highly erodible cropland from production will reduce erosion on that land, thereby improving air quality, water quality, and soil productivity. Planting trees or grasses on the enrolled cropland will not only decrease erosion but will also improve wildlife habitats. Enrolling irrigated land in regions with low static water levels and low well capacities saves scarce groundwater supplies, reduces pumping costs for other irrigators, and may ease the transition to a dryland-based agricultural economy for rural areas experiencing declines in groundwater supplies. (Static water level, at a point in time, refers to the level at which the aquifer water table settles after withdrawals.)

This report evaluates the effects of the CRP on natural resources and the benefits of those effects. We estimated economic benefits from changes in soil productivity, water quality, air quality, wildlife habitats, and groundwater supplies due to land enrolled in the CRP. We estimated these benefits under three different enrollment patterns. Data and procedures were not available to calculate benefits of a number of resource effects of the CRP, including the benefits from aesthetic improvement, increased populations of nongame wildlife and fish, and the recreational benefits associated with those improvements.

[1]Italicized numbers in parentheses refer to literature cited in the References section.

Goals and Approach of the Conservation Reserve Program

Goals

- Reduce erosion
- Protect soil productivity
- Reduce sedimentation
- Improve water quality
- Improve habitat for fish and wildlife

Directly affect the quality of natural resources

- Curb production of surplus commodities
- Provide income support for farmers

Approach

- Enroll 40-45 million acres
- Keep enrolled land out of production for a period of 10 years
- Pay operators annual rental payments and half the cost to establish permanent ground cover

Land Must Be Eligible for Farmers To Enroll in the CRP

Land must meet erodibility criteria to be eligible for the CRP. However, meeting these criteria does not necessarily mean that the land is unproductive. The Government helps compensate farmers for lost production and for establishing permanent cover crops.

Only certain types of land are targeted for enrollment in the CRP. In order to incite enrollment, USDA pays farmers rents to compensate for lost production and helps defray the cost of establishing permanent cover crops (such as grasses or trees) or other conservation practices (such as shallow water areas for wildlife or grass waterways).

Land Must Be Highly Erodible For Farmers To Sign Up

At least two-thirds of the offered field must be highly erodible to be eligible for the CRP. Under current regulations, highly erodible land must have certain characteristics and must meet erodibility criteria (see boxes for details). The Secretary of Agriculture may also include land that is not highly erodible but poses an environmental threat if farmed.

Producers enroll in the CRP during designated enrollment (signup) periods. During the signups, producers submit bids specifying the amount of eligible cropland they want to enroll, the annual rental payments they require for this purpose, and the cover crop they propose to plant to conserve the soil.

An application is accepted if the rental bid does not exceed the maximum rates (bid caps) established for designated areas and if the bid is consistent with market rents for comparable cropland. Each year, USDA will pay farmers for retiring cropland for a contract period of 10 years. The total annual rental payment may not exceed $50,000 per owner and will not affect payment limits under other Federal farm programs. USDA will also pay half of the cost of establishing permanent land cover.

Goal Is To Enroll 40-45 Million Acres

The Food Security Act requires that the CRP enroll no more than 45 million acres of cropland. At least 5 million acres were to be enrolled in fiscal year (FY, October through September) 1986, 15 million acres in FY 1987, 25 million acres in FY 1988, 35 million in FY 1989, and 40 million acres in FY 1990. The Food Security Act limits enrollment in any single county to 25 percent of the county's cropland, unless USDA determines that the local economy would not be hurt if more land were removed from production.

By the end of 1987, producers had five signup periods in which to enroll land. However, the amount enrolled in a year generally differs from the amount removed from production that year. For example, farmers can enroll land while the crops are in the ground. That land is actually removed from production in the next year. Farmers enrolled about 23 million acres of cropland during these periods, about 15.8 million acres of which

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Land Capability Classes (LCC's) as Established by USDA

Class I. Soils have few limitations that restrict use.

Class II. Soils have some limitations that reduce the choice of crops or that require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of crops or require special conservation practices, or both.

Class IV. Soils can be used for crops, but the choice is very limited and appropriate rotations and conservation practices must be used.

Classes V, VI, VII. Soils are not suited to cultivation but are suited to pasture, range, forage, trees, certain special crops, or wildlife habitat.

Class VIII. Soils are limited to recreation, wildlife habitat, or water supply uses.

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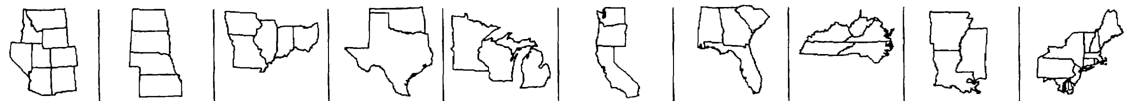
had been removed from production (7.2 million of the enrolled acres were to be removed during 1988) (fig. 1). (See Appendix for a discussion of subsequent enrollment.

Figure 1

Land retired from production in the CRP's first five signup periods



Region	Mountain	Northern Plains	Corn Belt	Southern Plains	Lake States	Pacific[1]	South-east	Appala-chian	Delta States	Northeast
States	ID UT MT CO WY AZ NV NM	ND SD NE KS	IA IN MO OH IL	OK TX	MN WI MI	WA OR CA	AL GA SC FL	WV NC KY VA TN	AR LA MS	ME MD PA MA NH RI CT DE NJ VT NY
1987 enrollment (1,000 acres)	3,320	2,759	2,671	2,504	1,475	1,080	777	634	546	82

1/ Pacific region excludes Alaska and Hawaii.

Measures of Erosion

"T" Marks the level of soil loss tolerance. That is, the maximum level of soil erosion that will permit a high level of crop productivity to be sustained economically and indefinitely.

"EI" Indicates the index of erodibilty. That is, the index measuring the erosion potential of a soil, independent of management or conservation practices. The erodibility index is a function of rainfall, soil erodibility, field slope and length, and T.

Four Kinds of "Highly Erodible" Land May Be Enrolled in the CRP

Under the regulations, highly erodible cropland is defined as:

1. Any land in LCC VI, VII, VIII

2. Land in LCC II, III, IV, V with erosion greater than 3T

3. Land in LCC II, III, IV, V with erosion greater than 2T but with gully erosion

4. Land with EI equal to or greater than 8 and erosion greater than 1T

Note: The Secretary of Agriculture may also include land that poses a potential threat to the environment.

All Impacts of CRP Completion Are Based on Three Regional Scenarios of Enrollment

The baseline scenario for CRP completion assumes continuation of present enrollment patterns, which are dominated by wind erosion regions. To evaluate the possible effects of the CRP on the environment, we considered two other scenarios, one in which more signups come from regions that tend to plant trees and another in which more signups come from regions with water quality problems.

As of the fifth signup period, enrollment was highest in regions where wind erosion was the greatest problem. If other CRP goals were emphasized, the pattern of enrollment would change as would the overall effects of the CRP on natural resources.

We examined what happens to enrollment patterns and natural resources if current enrollment continues toward CRP completion and if enrollment is completed under two alternative scenarios that shift the direction of the program to emphasize different goals, such as removing erodible cropland in environmentally sensitive areas or increasing the acreage planted to trees.

We estimated these effects for each farm production region so that regional comparisons could be made (fig. 1 details each region). The analysis assumes that the CRP can be targeted to certain areas through eligibility requirements and flexible caps on rental bids. The baseline scenario continues enrollment under the current rules and regulations *(10)*. The forestry scenario redirects the CRP to meet or exceed the Food Security Act's goal of planting trees on 12.5 percent of enrolled land. The environmental scenario includes, as part of the 45-million-acre program, 10.1 million acres that would yield the largest benefits to the environment.

Baseline Scenario Reflects Land Eligible for the CRP

Under the baseline scenario, the pre-1988 program rules and regulations continue, including bid caps, 25-percent limits on county enrollment, and eligibility requirements. The remaining signup periods are for land to be enrolled in 1988, 1989, and 1990. About 27 million acres of land were projected to be enrolled in 1988 *(10)*. Since 23 million acres were enrolled by the end of 1987, the baseline scenario allocates the additional 4 million acres to be enrolled in 1988 among regions, based on the distribution of land enrolled during the first five signups.

The remaining 18 million acres to be enrolled by 1990 were also regionally allocated, based on the enrollment pattern of the first five signups and the distribution of remaining eligible cropland. There are 101 million acres of highly erodible land eligible for the CRP. But, only 70 million acres are available for enrollment due to the 25-percent limit on enrollment of a county's cropland. Therefore, the projected distribution of the 45 million acres enrolled reflects a shift away from the currently observed enrollment pattern to one reflecting the distribution of land available for enrollment. Land enrolled for 1989 is an interpolation between the FY 1988 enrollment and the projected FY 1990 enrollment.

Enrollment prior to 1988 was heavy in the western regions, and the baseline projects that this trend will continue (table 1). However, because program requirements will start limiting enrollment in the West, participation in the Corn Belt is expected to increase by 1990.

Forestry Scenario Enrolls Acreage for Tree Coverage

The forestry scenario changes the enrollment pattern to improve the chance of achieving Congress' goal of tree coverage on 12.5 percent of enrolled cropland.[2] The share of new CRP land planted to trees in each region was assumed to double from that enrolled through 1987, except in the Southeast and Delta, where 50 and 70 percent of CRP acreage, respectively, had already been planted to trees.

In addition, enrollment was more concentrated in regions that tended to plant trees on CRP land through 1987. That is, this scenario expanded enrollment to 45 million acres by increasing program acreage in each region in proportion to the regional distribution of cropland planted to trees during the first five signups. This procedure results in 10-percent tree coverage nationally by 1990 if the CRP reaches 45 million acres.

[2]Congress intended in the Food Security Act that 12.5 percent of land enrolled in the CRP be planted to trees to the extent practicable.

The 1989 regional enrollment was also estimated by interpolating between the land enrolled in 1988 and estimated to be enrolled in 1990.

CRP enrollment under the forestry scenario differs from that under the baseline. The forestry scenario incorporates more land from the eastern regions (table 1). The Southeast and Lake States have almost double the land enrolled under the forestry scenario because forestry is more competitive with agriculture in these regions. The Corn Belt, Plains, and Mountain regions enroll considerably less land in the forestry scenario.

Environmental Scenario Enrolls Acreage From Low Water Quality Areas

Under the environmental scenario, 34.9 million acres of cropland would enroll along current trends (as in the baseline). This scenario also enrolls 10.1 million acres of land estimated to yield the largest environmental benefits.

Four million acres of CRP-eligible land were from aggregated subareas (ASA's) with water quality problems and with less than 5 percent of cropland enrolled in the CRP. ASA's are watersheds of major rivers for which there are data on discharges of agricultural residuals (fig. 2). Water quality for each ASA was defined in terms of average concentrations of suspended sediment, phosphorus, and Kjeldahl nitrogen (estimated with data from the National Stream Quality Assessment Network, NASQUAN) *(27)*. A watershed exhibited an agricultural water-quality problem if average ASA concentrations of these residuals were above threshold values for healthy aquatic environments *(46)*, and if agriculture was a major source of these residuals entering surface waters *(15)*.

About 6.1 million acres of cropland were projected to be enrolled from areas suffering from groundwater decline or salinity problems or from excessive wetness. While environmentally sensitive, these areas were not highly erodible. The average erosion rate for these areas fell much below that of the highly erodible land already enrolled.

Patterns of enrollment under the environmental scenario also shift from those in the baseline. The Plains and Mountain regions participate less under the environmental scenario (table 1). The Northeast, Delta, and Corn Belt enroll 60, 90, and 30 percent more land, respectively, because these regions have more of the wet soils and areas along bodies of water that we assumed would be enrolled under the environmental scenario.

Figure 2

There are 99 aggregated subareas in the contiguous States[1]

[1]Aggregated subareas are hydrologic units, usually the basins of major rivers, for which there are data relevant to the study of water quality.

Table 1 — Land retired from production under each CRP scenario, by region

Region	1987	Baseline	Forestry	Environmental
		1,000 acres		
Appalachian	634	1,969	2,550	1,886
Corn Belt	2,671	7,648	6,427	10,067
Delta	546	1,432	2,282	2,780
Lake States	1,475	3,788	6,667	3,865
Mountain	3,320	8,469	7,118	7,472
Northeast	82	730	614	1,116
Northern Plains	2,759	9,630	8,093	7,842
Pacific	1,080	2,649	2,227	2,620
Southeast	777	1,905	3,325	1,786
Southern Plains	2,504	6,779	5,697	5,565
Total	15,848	45,000	45,000	45,000

Effects Are Calculated According to Net Acres Removed Rather Than Amount of Land Enrolled

Farmers enroll land in the CRP while other farmers add other land to production at the same time because of economic changes brought about by the CRP. Thus, to calculate the CRP's effect on soil erosion, we must estimate net acres removed rather than merely the land retired through CRP enrollment.

If the CRP is successful in enrolling 45 million acres of cropland, the net area removed from production would probably be under 45 million acres. Commodity price increases and annual acreage reduction programs combine to effectively lower the area retired from production by an estimated 8 million acres *(45)*. Table 2 shows the net reduction in cropland in production due to the CRP for each scenario.

The CRP is not the only program that withdraws cropland. For example, farmers enrolling in commodity programs must remove some cropland from production as a requirement of those programs. Since producers participating in the CRP must idle a portion of their crop base, some of the land enrolled in the CRP would have been idled under an annual acreage reduction program.[3] Any benefits resulting from this idling should not, therefore, be credited to the CRP.

Land also comes into production because of higher crop prices, which are influenced by the CRP. Since the land enrolled in the CRP would have otherwise been in production, total crop production and stocks available for future use are reduced. The decline in crop production pressures commodity prices upward.[4] Higher prices induce farmers to put other pasture and fallow land into production, within the limits of existing commodity programs. The amount of cropland effectively removed from production by the CRP is, therefore, less than the 45-million-acre enrollment.

[3]The crop base is the amount of program cropland eligible for program benefits. A farm's acreage base for a crop is the average of acres planted and acres considered to be planted to the crop in the previous 5 years. But that average cannot exceed the average of acres planted and acres considered to be planted in the preceding 2 years. Considered planted acreage is acreage idled under acreage reduction or paid diversion programs, acreage prevented from being planted due to a disaster, and underplanted acreage planted to nonprogram crops other than soybeans or extra-long staple cotton.

[4]The effects of the CRP on crop production and prices were simulated using the Food and Agricultural Policy Simulator (FAPSIM). FAPSIM, an annual econometric simulation model, contains livestock and crop submodels that balance commodity prices and quantities under various policy assumptions *(28)*.

Table 2 — Net area that the CRP removed from crop production, by region [1]

Region	1987	Baseline	Forestry	Environmental
		1,000 acres		
Appalachian	527	1,732	2,311	1,636
Corn Belt	2,087	6,143	4,911	8,484
Delta	409	1,110	1,958	2,443
Lake States	1,136	2,746	5,613	2,793
Mountain	2,725	7,171	5,820	6,147
Northeast	34	503	380	882
Northern Plains	2,051	7,943	6,418	6,093
Pacific	909	2,170	1,746	2,130
Southeast	627	1,570	2,987	1,438
Southern Plains	2,113	5,881	4,807	4,635
Total	12,618	36,968	36,950	36,681

[1] Net area equals acreage enrolled in the CRP minus new cropland brought into production.

CRP Enrollment Reduces Erosion

Retiring highly erodible cropland can greatly reduce overall soil erosion. This effect is offset by the addition of other land brought into production, but only slightly, because the added land is likely to be much less erodible than the retired land.

Sheet, rill, and wind erosion moved over 3 billion tons of soil from farmland in 1982. Soil erosion can permanently reduce the productive potential of cropland, thereby reducing farmers' income. The eroded soil can be carried to surface waters and impose costs on water users. Soil eroded by wind can be carried far from the field and impose health and cleanup costs on homeowners.

CRP Reduces Amount of Soil Moved Off the Farm

The CRP should substantially reduce erosion because of the requirement that cropland be highly erodible to be eligible. On average, the CRP reduced the annual erosion rate by over 20 tons per acre on cropland enrolled through 1987 (table 3).

The average per-acre reduction in erosion declined over the first five signups. The land enrolled in 1986 averaged a 27-ton-per-acre reduction in erosion, which fell to an average of 23 tons after the 1987 signup.

Soil savings are expected to average about 17 tons per acre by the final signup of the baseline scenario. Total annual erosion reductions on the 45 million acres enrolled would be 750-780 million tons (table 4), or about a third of the erosion occurring on cropland that is eroding at rates greater than T. Once the CRP's retirement goal is met, the cumulative savings for the baseline scenario would be over 7.5 billion tons.

Both Types of Erosion Are Reduced

The magnitude of offsite benefits (benefits from erosion control that occur off the farm) in a region is largely determined by the type of erosion that is reduced. The net annual reductions in erosion at the end of 1987 are divided about evenly between sheet and rill erosion (types of erosion caused by water running over the soil surface) and wind erosion. Reductions in erosion east of the Mississippi River are primarily for sheet and rill erosion. Reductions west of the Mississippi River are primarily for wind erosion. After 1990, about 54 percent of the reductions in the baseline scenario would be for sheet and rill erosion.

Reductions in erosion are less in the forestry scenario than in the baseline because the enrollment criteria for cropland planted to trees are less stringent than for land planted to grasses. Starting with the sixth signup, land planted to trees need only to erode at twice the T value. Enrolling less erodible land under the forestry scenario results in 7 percent less reductions than under the baseline. But because the forestry scenario enrolls more land in the East, enrollment shifts away from regions characterized by wind erosion to regions characterized by sheet and rill erosion. Therefore, reductions in sheet and rill erosion increase.

The amount of erosion reduced under the environmental scenario is lower than in the other scenarios. The environmental scenario enrolls 6 million acres of nonerodible land, such as wetlands, land in groundwater decline areas, or saline land. This environmentally sensitive land is a significant portion of the land expected to be enrolled in the Northeast and Delta. Such a large share of nonerodible land generates much lower per-acre reductions in erosion for the land enrolled in these regions (table 3). However, a larger area is enrolled in these regions under the environmental scenario than under the baseline, resulting in little change in the overall reduction in erosion. Exchanging 6 million acres of nonerodible cropland for 6 million acres of highly erodible cropland lowers overall potential erosion reductions 12 percent from the baseline. But like the forestry scenario, the environmental scenario produces larger reductions in sheet and rill erosion because of higher enrollment in areas susceptible to these effects.

Net Reductions Are Slightly Lower

The net reductions in soil erosion from the CRP are actually less than the total data (table 4) indicate. We estimated the net reduction in soil erosion from the CRP (table 5) by subtracting from table 4 the erosion reduction on land that would have been in acreage reduction programs and the erosion increase on land taken out of pasture or fallow and put into production. The newly cultivated land was assumed not to produce much erosion because of the sodbuster and cross-compliance provisions of the Food Security Act. Under the sodbuster provision, farmers lose all USDA program benefits if they break new ground that is highly erodible without taking adequate precautions. Under the cross-compliance provision, farmers forfeit future eligibility for Federal farm programs if they farm existing highly erodible cropland without an approved conservation plan.

Table 3 — Average annual reduction in erosion per acre of land enrolled in the CRP, by region

Region	1986	1987	Baseline	Forestry	Environmental
			Tons per acre		
Appalachian	34	30	24	16	18
Corn Belt	25	20	16	15	14
Delta	27	23	19	14	8
Lake States	19	17	14	12	12
Mountain	30	24	17	18	17
Northeast	19	16	12	10	9
Northern Plains	25	20	14	15	14
Pacific	14	13	11	12	11
Southeast	19	17	14	12	13
Southern Plains	43	37	27	27	27
Average	27	23	17	16	15

Table 4 — Total annual reduction in erosion on land enrolled in the CRP, by region

Region	1987	Baseline	Forestry	Environmental
		Million tons		
Appalachian	19	47	41	34
Corn Belt	53	122	96	139
Delta	13	27	32	22
Lake States	25	53	80	46
Mountain	80	144	128	125
Northeast	1	9	6	10
Northern Plains	55	135	121	107
Pacific	14	29	27	29
Southeast	13	27	40	22
Southern Plains	93	183	154	150
Average	366	776	725	684

Table 5 — Net reduction in erosion on land enrolled in the CRP, by region [1]

Region	1987	Baseline	Forestry	Environmental
		Million tons		
Appalachian	19	47	40	33
Corn Belt	51	116	90	132
Delta	12	26	30	21
Lake States	24	48	75	42
Mountain	78	140	124	122
Northeast	1	8	6	10
Northern Plains	53	129	115	101
Pacific	14	28	27	28
Southeast	13	25	39	21
Southern Plains	91	180	150	147
Total	356	747	696	657

[1] Erosion reductions shown in table 4 minus erosion on newly cultivated land and erosion reductions which would have taken place on land in acreage reduction programs.

Less Erosion Improves Soil Productivity and Provides Economic Benefits

About 40 percent of U.S. cropland is eroding in excess of the rate assumed to lower productivity. This soil loss is costing U.S. farmers about $600 million a year in lost profits *(6)*. The CRP will slow this yield loss. And if farmers choose to return this land to production, their income will be higher than if the land had been continuously cropped.

The yield potential of American cropland is expected to be permanently reduced by 2 to 4 percent over the next century if erosion continues at 1982 levels *(1, 6, 35)*. Losses in profits and yield are incurred even though the Federal Government is spending over $1 billion per year on soil conservation, and farmers are spending at least that much to limit erosion.

Enrolling Preserves Productive Capacity

About 40 percent of U.S. cropland is eroding over the rate assumed to lower productivity *(35)*. The CRP targets the most erodible soils that are believed to suffer the greatest damage to productivity when cultivated. Retiring this land from production now will preserve its productive capacity.

Conserving soil by enrolling highly erodible cropland in the CRP can help delay yield losses and fertilizer cost increases, two of the largest effects following excessive erosion. Soil erosion may eventually reduce crop yields by lowering waterholding capacity, water infiltration rates, nutrient availability, levels of organic matter, and other beneficial characteristics of topsoil. Fertilizing more may alleviate or lessen some losses but will add to production costs.

Although fertilizing more might slow the yield declines caused by nutrients eroding with the soil, the yield loss from lower waterholding capacity may be permanent.

The value per ton of soil lost from erosion was estimated to range from a high of 79 cents in the Lake States to a low of 17 cents in the Mountain region (table 6). About 60 percent of the national average damage to productivity from erosion is caused by irreversible loss in potential yield; the remaining 40 percent is caused by increases in fertilizer applications, used to slow the loss in soil fertility.

Benefits of Enrolling Land Vary by Region and According to Enrollment Scenario

The present value of benefits of improved soil productivity for the baseline scenario would exceed $1.6 billion (table 7), assuming a 4-percent discount rate.[5] In the baseline scenario, the higher productivity of soil in the Corn Belt and the Lake States results in greater productivity benefits there than in the Mountain and Northern Plains, even though these regions have more land enrolled. The Southern Plains also receives high productivity benefits, but due mainly to high enrollment.

The other scenarios yield slightly lower benefits of soil productivity because those scenarios had smaller reductions in erosion. The estimated benefits in the forestry scenario are about 3 percent lower. Benefits in the environmental scenario are about 8 percent lower.

[5]Present value benefits are calculated on a discount rate, which is based on returns on capital. We assumed that 4 percent is the approximate long-term real rate of return on capital.

Table 6 — Average erosion-related damage to soil productivity, by region [1]

Region	Value of loss [2]		
	From yield	From fertilizer	Total
	Dollars per ton		
Appalachian	0.20	0.15	0.37
Corn Belt	.41	.25	.66
Delta	.17	.11	.28
Lake States	.56	.22	.79
Mountain	.07	.10	.17
Northeast	.52	.19	.70
Northern Plains	.13	.14	.27
Pacific	.10	.15	.26
Southeast	.14	.13	.27
Southern Plains	.09	.15	.24
U.S. average	.25	.17	.42

[1] Productivity losses over 100 years.
[2] Value of crop yields and fertilizers needed to replace lost nutrients.

Table 7 — Benefits to soil productivity from CRP enrollment, by region

Region	Baseline		Forestry		Environmental	
	Best [1]	Range	Best [1]	Range	Best [1]	Range
	Million dollars					
Appalachian	107	54-161	93	47-140	77	38-116
Corn Belt	473	236-709	374	187-561	532	266-799
Delta	46	23-69	54	27-81	37	18-55
Lake States	239	120-359	367	183-549	207	103-310
Mountain	150	75-225	134	67-201	131	66-197
Northeast	36	18-54	25	12-37	41	20-61
Northern Plains	216	108-324	195	98-293	172	86-258
Pacific	45	23-68	42	21-63	45	22-67
Southeast	43	22-64	64	32-97	36	18-54
Southern Plains	271	136-407	231	116-347	225	112-337
Total	1,626	815-2,440	1,579	790-2,369	1,503	749-2,254

[1] Benefits deemed most likely.

Method of Estimating Benefits of Improved Soil Productivity From CRP Enrollment

Future erosion on land that had been enrolled in the CRP would not cause the same level of damage as if the land had been continuously farmed. Our procedures simulated the benefits of improved soil productivity by looking at how annual yield and fertilizer use change when a ton of soil is eroded, and the resulting savings once highly erodible land is in conserving uses for a period of time.

We used a two-part procedure to estimate benefits to soil productivity due to CRP enrollment. We first determined the erosion (wind and water) reductions from the CRP by county, land use (grain and nongrain cropland), and RCA (Soil and Water Resources Conservation Act) soil group (a soil-classification system that divides the numerous land classes/subclasses into eight groups, based on agricultural production potential). We then determined the benefits of improved soil productivity over time for each region. To determine productivity benefits, we estimated the benefits per ton of erosion reduced for each combination of the above conditions and applied them to the data on CRP reductions in erosion rates.

Determining Erosion-Related Damage

We obtained expected yield losses and fertilizer cost increases due to soil erosion from a comprehensive yield/soil loss model, called the Erosion Productivity Impact Calculator (EPIC), that Federal researchers developed for the second RCA appraisal *(44).*

The model simulated 12,000 combinations of geographic regions, soil groups, crops, tillage, and conservation practices over the next 100 years. For each combination, the model regressed cumulative erosion for each year on predicted annual yield and fertilizer use to obtain the average change in yield and fertilizer use due to a ton of erosion.

Calculating Value of Damage per Ton of Eroded Soil

We then estimated the economic value of damage per ton of eroded soil. To determine a dollar value per ton of soil lost for all the combinations of conditions in each region, we multiplied the per-ton changes in yield and fertilizer use by the prices of crops and fertilizers (prices were assumed to remain constant[6]). Aggregating these values generated weighted regional damage per ton. We then adjusted the estimates downward to account for the loss in potential yield over the 10 years that enrolled cropland would be retired from production (table 6).

Estimating Benefits of Improved Soil Productivity

Benefits of improved soil productivity due to CRP enrollment were estimated by multiplying regional damage per ton by net savings in soil.

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[6]Although prices could fluctuate annually from changes in weather and demand, we assumed that the long-term average real price would not change enough to significantly alter the results.

Modeling the Improved Soil Productivity Due to CRP Enrollment

We first used the EPIC yield/soil loss model to:

Generate--

- Yield losses and fertilizer cost increases over 100 years due to erosion on 12,000 combinations of regions, soils, crops, and farming practices that might occur over 100 years

Determine--

- Cumulative erosion for each year

- Average change in yield and fertilizer use due to a ton of erosion

We then used those regression estimates to calculate:

The value of damage per ton of eroded soil--

- For all combinations of conditions

- For weighted regional groupings (data adjusted for loss in yield due to land out of production and enrolled in the CRP for 10 years)

The value of benefits:

- For regional groupings

Agricultural Production Is Related to Surface Water Quality

Cropland erosion may do more damage to waterways off the farm than to crop yields on the farm. Reducing the level of soil eroding from farmland may result in cleaner surface water, which would generate substantial economic benefits to water users both at and away from the farm.

By reducing farmland erosion, the CRP improves water quality. When cropland erodes, the soil can carry agricultural chemicals and byproducts or residuals into waterways, which can harm water users downstream. Sediment, pesticides, and nitrogen and phosphorus nutrients (primarily from chemical fertilizers and animal manure) are the major agricultural residuals carried into waterways.

Residuals Generated From Agricultural Production

Sediment washing off cropland and into waterways can fill reservoirs, block navigation channels, interfere with water conveyance systems, affect aquatic plant life, and degrade recreational resources. By filling stream channels, sediment can also increase the frequency and severity of floods.

Pesticides reaching waterways can affect aquatic plant and animal life, and sufficient quantities in drinking water may endanger human health.

Nutrients in waterways from chemical fertilizers and animal manure may promote the premature aging (eutrophication) of lakes and estuaries, affecting water-based recreation, municipal and industrial water use, and commercial fishing. Nitrates from fertilizers in drinking water supplies can also pose risks to human health.

Residuals Get Carried Downstream

Agricultural activities are the most pervasive cause of water-quality problems from nonpoint sources; that is, broad and not usually distinct source areas, rather than a concentrated entry point, such as a drainage pipe. National studies suggest that agricultural nonpoint source pollution harms portions of over two-thirds of the Nation's river basins *(41)*. A survey of fisheries reports that agricultural nonpoint sources appear to lower water quality on more stream miles than any other category of pollution source *(20)*. Suspended sediment and nutrients from agricultural sources are cited as the most damaging pollutants from nonpoint sources *(30)*. Recent assessments suggest that non-point source pollution may obstruct national water-quality goals, even after planned point-source controls are completely implemented.

The CRP Could Improve Water Quality

Recent estimates indicate that cropland erosion may do more damage off the farm than on the farm *(5, 6, 32)*. Clark, Haverkamp, and Chapman made the first comprehensive estimates of offsite damage from soil erosion *(5)*. They estimated that soil eroding from all sources resulted in $6.1 billion (1980 dollars) in damage to in-stream water uses (such as recreation, water-storage facilities, and navigation) and off-stream water uses (such as water-conveyance facilities and water-treatment facilities). They attributed about $2.2 billion of this damage to cropland erosion.

The CRP has a large potential to significantly reduce the amount of agricultural residuals discharged into surface water because of the large amount of highly erodible or environmentally sensitive cropland to be enrolled. According to a recent evaluation of soil conservation programs, targeting soil conservation programs to the most rapidly eroding land would substantially increase offsite benefits *(32)*.

Table 8 — Annual offsite damage from soil erosion[1]

Region	Offsite damage		Damage per ton of erosion
	Best [2]	Range	
	Million dollars		*Dollars*
Appalachian	688	379-1,100	1.41
Corn Belt	1,111	546-1,968	1.15
Delta	592	362-1,984	2.44
Lake States	676	361-1,085	3.74
Mountain	871	489-1,333	1.12
Northeast	1,317	786-2,632	7.06
Northern Plains	381	215-1,692	.57
Pacific	1,680	1,037-3,228	2.48
Southeast	479	292-676	1.92
Southern Plains	990	565-1,907	2.02
Total	8,785	5,052-17,605	1.78

[1] Includes all sources of erosion (not just cropland), such as rangeland, pastureland, and forestland.
[2] The most likely extent of offsite damage.
Source: *(27)*.

Improved Surface Water Brings Economic Benefits to Users Downstream

Reduced cropland erosion and nutrient use improve water quality. But the regional benefits of such improvements vary according to soil erodibility and demand for water resources.

Water quality improves when the CRP reduces erosion and nutrient use on cropland by removing highly erodible land from production. This occurs for all scenarios of CRP completion. But scenarios with the largest reductions in erosion do not necessarily produce the largest benefits from improved water quality. Benefits are generally largest when enrollment comes from areas with the greatest offsite damage from sheet and rill erosion.

Baseline Benefits When Damage Is High

The estimated present value of benefits of improved off-site water quality ranged between $1.9 billion and $5.3 billion when enrollment continues under the current trends in the baseline. The most likely estimate of benefits is $3.6 billion, or about $79 per acre, assuming a 4-percent discount rate (tables 9 and 10).

The benefits of improved water quality varied by region, depending on the damage. The Appalachian and Delta regions received the highest per-acre benefits. These regions also had the highest per-acre reductions in sheet and rill erosion for land enrolled in the CRP. But while per-acre reductions were relatively high in the Corn Belt, the damage per ton of erosion there was very low because of a relatively low demand for water resources. As a result, regions with modest per-acre reductions in erosion but with high damage per ton of erosion, such as in the Northeast, received much higher benefits per acre.

Forestry, Environmental Benefits Are Higher

Enrollment under the forestry scenario produced 15.6-percent higher water-quality benefits than under the baseline (table 9). These larger benefits stemmed from the forestry scenario shifting enrollment to areas east of the Mississippi River, areas with high levels of sheet and rill erosion (instead of the land west of the Mississippi River enrolled in the baseline, areas with high levels of wind erosion). Water-quality benefits increased markedly in the Lake States, Delta, Southeast, and Appalachian regions.

Benefits from improved water quality under the environmental scenario exceeded those under the baseline by 13.3 percent (table 9). As with the forestry scenario, CRP enrollment shifted away from wind erosion areas in the Western States toward the sheet and rill erosion areas of the Eastern States. The Corn Belt, Delta, and Northeast regions showed the largest increases in benefits for improved water quality.

Table 9 — Benefits of improved water quality due to CRP enrollment, by region

Region	Baseline		Forestry		Environmental	
	Best [1]	Range	Best [1]	Range	Best [1]	Range
			Million dollars			
Appalachian	407	160-656	475	187-766	397	157-641
Corn Belt	584	273-895	526	246-806	746	349-1,142
Delta	376	231-531	656	387-958	766	471-1,082
Lake States	406	232-579	676	387-958	415	238-589
Mountain	458	248-673	402	218-590	416	225-610
Northeast	127	76-179	109	65-153	191	114-269
Northern Plains	306	162-459	270	143-406	267	141-400
Pacific	275	152-406	240	133-354	273	151-402
Southeast	280	167-400	460	274-657	268	160-382
Southern Plains	338	181-500	299	160-443	296	158-438
Total	3,557	1,882-5,278	4,113	2,217-6,060	4,035	2,164-5,955

[1] Benefits deemed most likely.

Table 10 — Per-acre benefits of improved water quality due to CRP enrollment, by region

Region	Baseline		Forestry		Environmental	
	Best [1]	Range	Best [1]	Range	Best [1]	Range
			Million dollars			
Appalachian	206	81-333	186	73-300	211	83-340
Corn Belt	76	36-117	82	38-125	74	35-113
Delta	262	161-371	287	177-406	276	69-389
Lake States	107	61-152	101	58-144	107	62-152
Mountain	54	29-79	56	31-83	56	30-82
Northeast	174	104-245	177	106-249	171	102-241
Northern Plains	32	17-48	33	18-50	34	18-51
Pacific	104	57-153	108	60-159	104	58-153
Southeast	147	88-210	138	82-198	150	90-214
Southern Plains	50	27-74	53	28-78	53	28-79
Total	79	42-117	91	49-135	90	48-132

[1] Benefits deemed most likely.

Method of Estimating Benefits of Improved Surface Water Quality From CRP Enrollment

Economic benefits of the CRP on natural resources must account for the physiologic, hydrologic, and economic links between soil erosion and the water supply. We used several methods to link regional changes in agricultural residuals in the waterways with effects on the many groups of water users.

Removing cropland from production and reducing erosion generates benefits to water users by reducing the amount of sediment and nutrients in waterways. Cropland is only one source of these materials. Point sources, such as sewage-treatment plants, and other nonpoint sources, such as forests and rangeland, discharge residuals into waterways.

We estimated the CRP's benefits to regional water quality, based on damage from soil erosion and erosion-induced flooding, to different categories of water users: recreational fishing, navigation, water storage, irrigation ditches, roadside ditches, water treatment, municipal and industrial water use, and steam cooling. The procedures for estimating benefits recognized the physical, chemical, hydrologic, and economic links between the movement of soil and chemicals on the field and the effects on downstream water users (fig. 3).

Determining the Amount Discharged and Changes in Concentrations

We estimated regional changes in the discharge of suspended sediment, organic nitrogen, and phosphorus for given changes in erosion and acreage using data developed by Resources for the Future for sediment delivery, nutrients attached to sediment, and nutrients dissolved in runoff *(15)*. For example, once all 45 million acres are removed from production under the baseline scenario, the CRP could reduce the total annual discharge of suspended sediment by 8.6 percent, organic nitrogen by 9.2 percent, and phosphorus by 7.4 percent *(27)*.

We then estimated related changes in the concentrations of these materials in receiving waters by using water-quality models estimated for each ASA *(27)*. ASA's were used as the basis of evaluation because watersheds are the logical unit of study for water-quality issues, and because data were available for these regions. These models specify average concentrations of sediment or nutrients in water as a function of regional discharge levels and the volume of streamflow.

Estimating Benefits of Less Damage

Several different methods helped us link changes in delivery or concentrations of residuals with the economic effects of water-quality changes on water users. Different procedures were used, depending on the information available about the links between erosion and offsite damage. [Detailed descriptions of the methods appear in Ribaudo *(27)*].

We estimated the effects of improved water quality on recreational fishing activity with a fishing participation model. The model's data came from the 1980 National Survey of Hunting, Fishing, and Wildlife-Associated Recreation and from NASQUAN. The model predicted changes in the number of persons fishing and in the number of days they fished when regional water quality changed. Each fishing day was valued at $25 *(22)*.

A model of water-treatment costs helped us estimate changes in costs of municipal water treatment from reductions in turbidity (a measure of suspended sediment). The model specified water-treatment cost as a function of turbidity, the amount of water treated, and the costs of other inputs *(18)*. Changes in turbidity were easily estimated from changes in concentrations of suspended sediment. We assumed that water quality is a perfect substitute with turbidity-reducing inputs in the treatment process, and that the change in treatment cost does not affect the output of treated water. Benefits, therefore, equal the reduction in costs of treating water *(13)*.

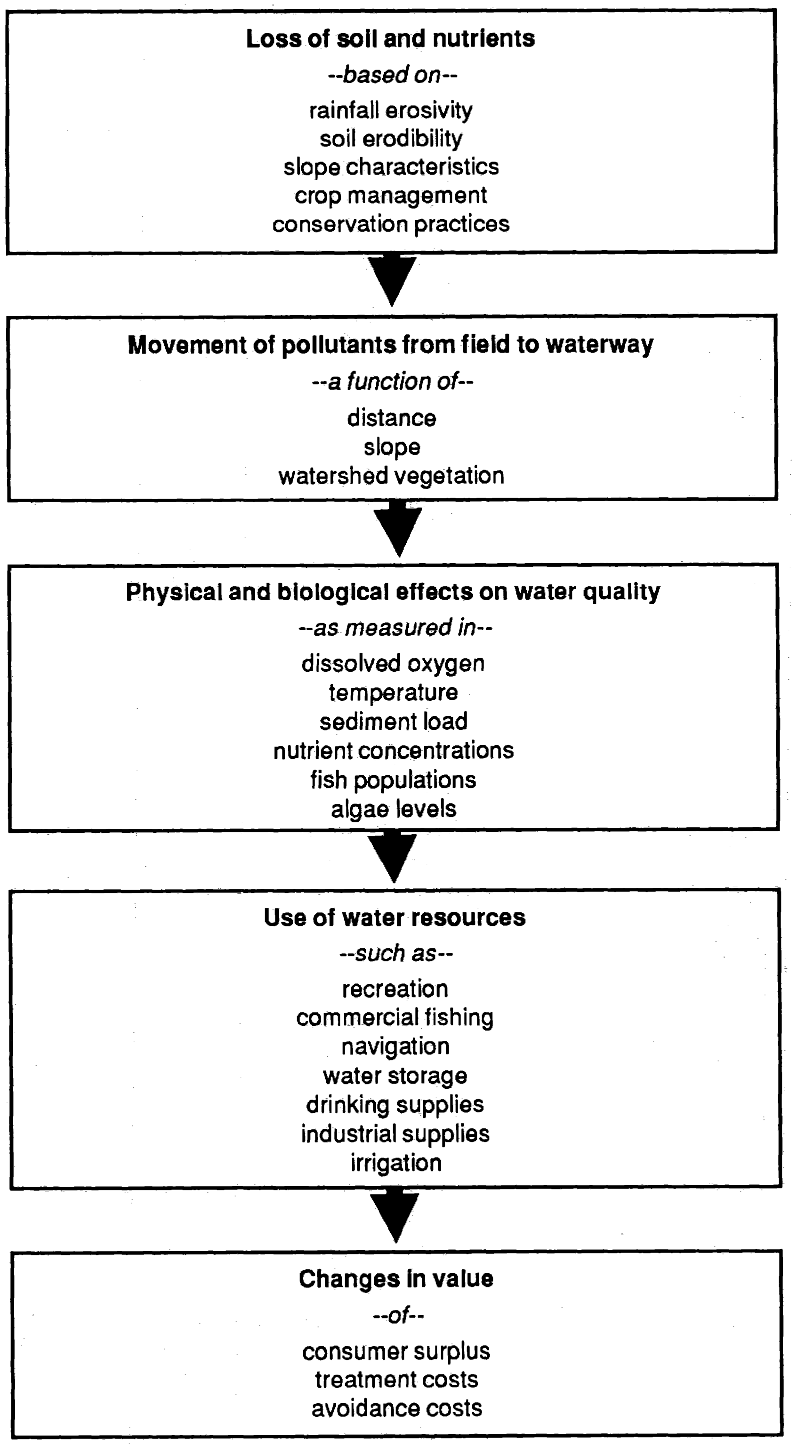
We estimated effects of reduced erosion on roadside ditch maintenance by using a damage cost model that links gross erosion to reductions in ditch maintenance costs. The model was estimated with State data on maintenance costs for roadside ditches. Costs were specified as a function of gross erosion, road mileage, and unit removal costs. Each 1,000-ton reduction in annual erosion reduced maintenance costs by $79 *(27)*.

We estimated benefits to irrigation ditches by assuming a linear relationship between damage (maintenance costs) and erosion. Under this relationship, a percentage reduction in erosion generates a similar reduction in damage. We obtained irrigation ditch maintenance costs from the Census of Agriculture *(38)*.

Benefits to other damage categories (navigation, flooding, municipal and industrial use, and water storage) were also estimated by assuming a linear relationship between sediment discharge and damage, such that a reduction in discharge reduces a similar share of damage. Clark, Haverkamp, and Chapman provided the damages from flooding and to municipal and industrial users *(5)*. The Army Corps of Engineers provided the damages to navigation (in the form of dredging costs). Damages to water-storage facilities were obtained from Crowder *(7)*.

Figure 3

Soil eroded from farmland is linked with damage off the farm



Agricultural Production Can Affect Air Quality

Wind is the dominant form of erosion west of the Mississippi River, where CRP enrollment is highest. The CRP can reduce wind damage to cropland there and can also reduce related damage downwind from the farm, such as from particulate air pollution.

Enrolling highly erodible cropland in the CRP and planting some type of permanent cover or windbreaks on that land can help curb wind erosion and related damage. Benefits of reduced wind erosion from CRP enrollment could be substantial, because the regions that were most susceptible to wind damage also had the highest enrollment as of the end of 1987.

Wind Moves Soils in the West

Although wind erosion accounted for only 37 percent of the total tonnage of soil eroded in 1982, wind is the dominant form of erosion in the Western States. Many areas west of the Mississippi River experience low average rainfall, frequent drought, and relatively high wind velocities. These conditions, when combined with fine soils, sparse vegetative cover, and agricultural activity, make some western regions susceptible to wind erosion.

According to USDA's Soil Conservation Service (SCS), wind eroded about 1.1 billion tons of soil from cropland in 1982, over half (about 57 percent) of the total amount of soil eroded by wind and water *(37)*. Wind erosion damaged an average of 4.8 million crop acres in the Great Plains each year since 1955 *(2, 14)*.

In addition to damaging cropland in the western regions, wind erosion significantly contributed to particulate air pollution away from farms, particularly in some areas in the arid southwest and Great Plains. Average annual concentrations of particulates due to industrial sources are low in most western regions. But, wind erosion can produce short-term rural levels of particulates that exceed urban levels *(17)*. Environmental Protection Agency studies have shown that agriculture significantly contributes to air pollution in the San Joaquin area of California, the Phoenix-Tucson area of Arizona, the Las Cruces area of New Mexico, and the Lubbock area of Texas *(21, 26)*.

Wind Erosion Poses Costs in the West and Elsewhere

Offsite damage of wind erosion stems from particulate-related costs imposed on those living or working downwind from blowing soil. Such costs include cleaning and maintenance of businesses and households, damage to nonfarm machinery, and adverse effects on health *(19)*.

Wind Erosion Causes Damage When Soil Dust and Other Particulate Matter Become Airborne

Areas most susceptible generally face:

- low average rainfall
- frequent droughts
- high wind velocities

Which combine with:

- fine soils
- sparse vegetative cover
- farm/agricultural activities

To damage farms:

- 1.1 billion tons of soil moved
- 4.8 million crop acres damaged
- particulate air pollution

And pose costs to society downwind:

- cleaning and maintenance for businesses and households
- maintenance and repair of nonfarm machines
- health risks

Enrolling Land in the CRP Provides Economic Benefits When Wind Erosion Is Reduced

Enrolling highly erodible cropland in the CRP and reducing wind erosion improves air quality, especially in the Western States. Benefits are about the same regardless of the patterns by which CRP enrollment goals are completed.

The CRP improves air quality by reducing potential wind erosion (with less land in active crop production) and by protecting the soil (with more erodible land planted to trees and a cover of permanent grasses). Improved air quality produces the largest benefits where rates of soil erosion are high and where population levels are moderate.

CRP Produces Large Benefits

Estimating offsite benefits of reduced wind erosion due to CRP enrollment is difficult due to limited data and a poor understanding of the response of households to blowing soil *(25)*. But, the size of the estimates indicate that the CRP may generate substantial benefits in the Western States because those regions are the most susceptible to wind damage and have high CRP enrollment.

The estimated present value of offsite household wind-erosion benefits from the baseline scenario of the CRP is significant, ranging between $0.4 and $1.1 billion, with the most likely estimate being $0.5 billion, assuming a 4-percent discount rate (table 11). About 40 percent of the wind-erosion benefits occur in the Mountain region.

Benefits the Same, Regardless of Enrollment Scenario

Benefits vary more among regions in the baseline scenario than among the scenarios themselves. The average present value of wind-erosion benefits per acre for the baseline ranges from $11 in the Pacific to $26 in the Mountain region (table 11). The forestry and environmental scenarios generated approximately the same benefits from reduced wind erosion as the baseline.

Table 11— Benefits of improved air quality from reduced wind erosion under the baseline scenario, by region

Region	Benefits		Per-acre benefits	
	Best [1]	Range	Best [1]	Range
	Million dollars		*Dollars*	
Mountain	217	153-440	26	18-52
Northern Plains	148	109-312	15	11-32
Pacific	28	25-72	11	9-27
Southern Plains	155	99-282	23	15-42
Total	548	386-1,106	12	9-25

Note: Wind erosion was not a problem in the Appalachian, Corn Belt, Delta, Lake States, Northeast, and Southeast regions.
[1] Benefits deemed most likely.

Method of Estimating Benefits of Improved Air Quality From CRP Enrollment

Limited data hinder calculating benefits from improved air quality due to CRP enrollment. We derived economic benefits from a model on wind erosion-related damage estimated with data from a New Mexico survey.

The benefits of improved air quality from CRP enrollment are based on levels of offsite damages to households from wind erosion in the Western States *(25)* and on the level of wind erosion reduced by the CRP.

We used an economic framework to estimate the offsite benefits from reduced wind erosion. Our framework specified benefits as equal to the decline in household damage after the CRP reduces wind erosion. The damage was generated with a damage model, estimated with data on household damages in New Mexico [obtained from a statewide survey of wind-erosion damages, see *(19)*]. The model specified household damage from wind erosion as a function of the wind-erosion rate, income, and ownership characteristics (such as owner/renter and years in residence).

We then used the damage model to estimate damages per household for each county in the western regions where wind erosion is predominant. The National Resources Inventory (NRI, an inventory of U.S. land resources) provided the county wind erosion data. The Bureau of the Census, U.S. Department of Commerce, provided the housing and income data.

Damage per household was then re-estimated with the wind-erosion rates occurring after the CRP is in place. Offsite benefits per household were then determined by subtracting the damage with the CRP in place from the damage without the CRP in place. The estimated benefits per household were then multiplied by the number of households in each county.

The benefits represent expenditures made by households to reverse the effects of blowing soil, such as sweeping windblown soil off sidewalks or cleaning dust inside the home. Benefits may be underestimated because many could not be quantified with this procedure. For example, benefits to businesses and governments and benefits from lower health risks are not included. Benefits from nonexpenditure damage, such as reduced discomfort from less dust in the air, are similarly excluded.

Problems of underestimating nonexpenditure damages are likely minor when compared with problems associated with extrapolating survey results from a small region to a large region. Therefore, this report presents a wide range of benefits to account for uncertainty in the relationship between wind-erosion rates and offsite damages.

About the New Mexico Survey

There are few studies on offsite damage from wind erosion. The New Mexico survey is one of the only studies with data on damage to use when estimating benefits of reduced wind erosion on air quality *(19)*. The study identified the level of wind erosion in surrounding areas and the costs to farms, businesses, and households downwind from the eroded land. Costs included increased cleaning and maintenance for businesses and households, damage to machinery, and adverse health effects.

In the survey, households were asked to estimate the level of soil-related particulate matter in and around their home and work and to identify problems associated with the quality of air. Major problem areas included breathing problems; frequent dusting, sweeping, and general cleaning; and reduced performance of vehicles and nonfarm machinery.

Other findings include ...

- 71 percent reported that blowing dust increased the need for interior cleaning and laundry
- 67 percent experienced negative effects on landscaping
- 54 percent reported negative effects on outdoor recreation
- 50 percent said their automobiles were affected
- 41 percent complained of damage to exterior paint
- 35 percent suffered health problems

Agricultural Land Use Directly Affects Wildlife Habitat

Changes in agricultural land use are correlated with declining populations of wildlife species. If the CRP enrolls 45 million acres of cropland, the quality and diversity of habitat for fish and wildlife will markedly improve on over 10 percent of U.S. cropland.

Familiar wildlife species associated with agricultural land include the ring-necked pheasant, bobwhite quail, cottontail rabbit, meadowlark, white-tailed deer, killdeer, and barn owl. These species use cropland, grassland, and remnant habitats such as hedgerows, woodlots, and wetlands for nesting, feeding, and escaping predators.

Land Use Changes Affect Habitats, Populations

Many remnant habitats, often viewed as unproductive, have been converted to cropland production. This conversion is particularly evident in areas where agricultural production is most intensive, such as in the Corn Belt and Northern Plains.

Several studies have been conducted to assess land-use changes over the last 30 years and the effects on wildlife. Most studies compare land use of the 1950's to the late 1970's (viewed as a time of serious losses in wildlife habitat). Fence-row to fence-row production of crops eliminated hedgerows, windbreaks, grassy borders, and other types of habitat. Wetlands were drained to produce crops. Farmers increased land devoted to row crops in some areas by replacing small grain, hay, and pasture land. Row crops are less conducive to supporting wildlife than are small grains, hay, and pasture that provide cover and nesting as well as food.

Other studies illustrate changes in land use that harm wildlife. Warner and Etter estimated that row crop production in Illinois has increased 48 percent since 1962, farm size has increased 37 percent, and hay and oat acreage has decreased 82 percent *(43)*. Row crop acreage in Indiana increased 46 percent between 1960 and 1978, acreage in small grains decreased 54 percent, hay acreage decreased 33 percent, and pasture acreage decreased 29 percent *(9)*. Taylor, Wolfe, and Baxter compared two areas in Nebraska in 1955, 1964, and 1976 *(34)*. Land-use changes in these areas, primarily after 1964, followed the same trend as cited above.

These shifts in farmland use have been correlated with changes in populations of farmland wildlife. In the Nebraska study, decreases in pheasant densities paralleled land-use changes *(34)*. Diversifying farming by mixing different land uses (such as for pasture, small grains, and row crops) in one area was significantly correlated with pheasant densities: the greater the interspersion index, the higher the pheasant densities. Declining hunter harvest (indicating species populations) of cottontail rabbits, bobwhite quail, and pheasants was significantly correlated with both increasing row crop acreage and declining area planted to hay and small grains between 1956 and 1983 in Illinois *(4)*. Cottontail populations have declined 90-95 percent in eastern Illinois, the most intensively farmed area in the State. Statewide populations have decreased 70 percent over 23 years *(11)*. Key species of grassland birds have declined 90 percent in Illinois since 1957 *(16)*.

Biologists from 14 States, primarily in the Midwest and Northern Plains, compared farmland wildlife populations of the late 1950's and early 1960's with those in the late 1970's. Pheasant populations in 12 States declined between 33 percent and 96 percent; cottontail populations in 4 States declined between 31 percent and 72 percent; and bobwhite quail populations in 4 States declined between 7 percent and 80 percent. All States exhibited the same land-use trends: increasing area of row crops and decreasing area of small grains, hay and pasture, wetlands, edge habitat, and idle lands *(12)*.

CRP Improves Prospects for Wildlife

Adding permanent vegetative cover around cropland generally benefits farmland species, including upland game, ground-nesting birds, small mammals, and other grassland-dwelling species. Waterfowl should also benefit from increased nesting cover adjacent to wetlands.

Several factors influence how well the CRP can improve or increase wildlife populations. A primary factor is the type of vegetation established. Native grasses and legumes are highly desirable because they are best able to support native grassland species. In the early years, acreage planted to trees will provide cover for many species, but species composition will alter as the trees mature. Another factor is the quality of the cover established, in terms of height and density, which is related to the chosen mix of vegetation. Interspersing retired lands with other land uses, such as planting to a food-providing crop, is also important.

Wildlife recreationists, a large proportion of the U.S. population, are the primary group benefiting from increases in wildlife populations. Hunters would enjoy higher numbers and quality of species when hunting (consumptive uses). Increased wildlife habitat would also provide recreationists with more opportunities for enjoying other activities such as birdwatching, photographing, hiking, and picnicking (nonconsumptive uses).

Changes In Land Use Directly Affect Habitats

Wildlife associated with farmland:

- ring-neck pheasant
- bobwhite quail
- cottontail rabbit
- meadowlark
- white-tailed deer
- killdeer
- barn owl

Found In:

- cropland
- grassland
- hedgerows
- woodlots
- wetlands

"Remnant habitat"--many viewed as unproductive and converted to farmland

To:

- feed
- cover or escape predators
- nest

Enrolling Land in the CRP Provides Economic Benefits to Recreationists by Improving Habitats

Enrolling land in the CRP will create new grassland habitat for several species, primarily small game. Small game hunters are, therefore, one group of recreationists that receive most of the economic benefits from improved habitats, but only in areas with new grassland added to the habitat base.

Benefits to hunters occur only with increased participation, which is based on increased availability of habitat, primarily from new grassland. Enrolling cropland in the CRP had little effect on total availability of habitat (forestland, pasture, and rangeland).

The percentage change in grassland was significant in some regions. The Lake States and Corn Belt received the largest benefits in all three scenarios of CRP completion. These regions had a large area enrolled in the CRP and the largest percentage increases in grassland. Although the Western States had high CRP enrollment, the changes in the amount of grassland there were very small because of the large area of rangeland already present.

More Frequent Small Game Hunting in the Baseline

The present value of benefits to small game hunters under the baseline scenario ranged between $2.9 and $4.7 billion. The most likely estimate is $3.8 billion, assuming a 4-percent discount rate (table 12). Most benefits came from additional participation in small game hunting by existing hunters.

Forestry Scenario Generates Largest Benefits to Hunters

The forestry scenario resulted in the greatest benefits of improved wildlife habitats due to CRP enrollment. These benefits ranged between $3.8 and $6.1 billion. The areas enrolled for tree planting were treated as grassland since these areas can function as grassland-type habitat in the early years of establishment. The value of land planted to trees will decline over time for small game species, but other species will replace them and benefit from the new habitat.

Environmental Scenario Also Provides Benefits to Hunters

Benefits in the environmental scenario are probably underestimated. The estimated benefits ranged between $3.5 and $5.6 billion. The types of area enrolled in this scenario are likely to be of higher quality than those in the baseline or forestry scenarios since the environmental scenario includes enrollment of wetlands. Wetlands have a greater effect on increasing populations of species. However, the analysis ignores quality differences and treats all land enrolled equally.

Table 12 — Hunting benefits from improved wildlife habitat due to CRP enrollment, by region[1]

Region	Baseline		Forestry		Environmental	
	Best [2]	Range	Best [2]	Range	Best [2]	Range
			Million dollars			
Appalachian	326	250-402	421	323-519	310	238-382
Corn Belt	846	649-1,043	707	542-872	1,084	832-1,336
Delta	243	186-300	400	307-493	483	370-595
Lake States	1,470	1,128-1,812	2,336	1,792-2,880	1,488	1,141-1,834
Mountain	18	14-22	15	12-18	16	12-20
Northeast	368	282-454	285	219-351	620	476-764
Northern Plains	100	77-123	82	63-101	79	61-97
Pacific	34	26-42	28	21-34	34	26-42
Southeast	378	290-466	651	499-803	342	262-422
Southern Plains	67	51-83	56	43-69	54	41-66
Total	3,848	2,953-4,747	4,979	3,821-6,140	4,509	3,459-5,558

[1] Hunting day valued at $36.50.
[2] Benefits deemed most likely.

Method of Estimating Benefits of Improved Wildlife Habitat From CRP Enrollment

Improving wildlife habitat is an important goal of the CRP. We gathered data from a variety of sources to estimate the economic benefits of the CRP improving habitats by protecting erodible soils with vegetative cover.

Our benefit estimates are restricted to those received by hunters on private CRP land. Because the CRP is restricted to private cropland, those engaging in wildlife-related activities on public lands are assumed not to benefit from improved wildlife habitats. While indirect benefits may occur from wildlife moving from private to public land, there were no estimates available for the value of wildlife in nonconsumptive uses.

Detailed Data Gathered From Varied Sources

The primary source of data for the analysis of economic benefits is the 1980 National Survey of Fishing, Hunting, and Wildlife Associated Recreation (NSFHW) conducted by the U.S. Bureau of the Census for the U.S. Fish and Wildlife Service. This survey identified participants in wildlife recreation activities throughout the Nation and reported consumptive and nonconsumptive activities. The data include socioeconomic information and detailed information about the location and duration of recreational activities. We obtained supplemental data on State availability of habitat and State demographics from the National Resources Inventory, Bureau of the Census, and from Federal reports of the Bureau of Land Management, Forest Service, and U.S. Fish and Wildlife Service.

Method Restricted to Hunting Participation

Enrolling land in the CRP will create new grassland habitat for several game species, primarily small game. We, therefore, estimated benefits according to participation in small game hunting. Previous studies have shown that habitat availability affects the hunter's decision to hunt *(23, 42)*, indicates game populations, and affects the type of hunting in which a hunter will participate. Therefore, hunter response to increases in habitat due to the CRP is expected to occur when more of the general population participate as new hunters and when existing hunters go more often for small game. Participation of new and existing hunters was estimated separately when calculating the effects and benefits.

Participation rates for hunters among the general public (over 16 years old) were derived from the 1980 NSFHW survey for each region. We estimated the habitat availability for all hunting according to the sum of forestland, pastureland, and rangeland in a hunter's resident State (the habitat variable). Walsh, Harpman, John, McKean, and LeCroy estimated an equation for the probability of hunter participation using the same habitat variable and other socioeconomic variables *(42)*. We used this model to estimate how hunting participation changes when habitat availability changes.

To calculate changes in participation rates for each year, we adjusted the habitat variable by the CRP acres for each year of the program (1986-99) and inserted the variable in Walsh's model. The new rate was then used to estimate the number of new hunters that participate because of habitat added by the CRP. Each new hunter was assumed to aim primarily for small game. We assumed that new hunters would hunt the same average number of days as existing small game hunters in the region. Multiplying average days by number of new hunters resulted in total days of hunting by new hunters for each year of the CRP.

The increase in available habitat is expected to entice more existing hunters to participate in small game hunting. We estimated participation equations by region to predict the probability of a hunter being a small game hunter. The resulting equation was then used to estimate, for each program year, the increase in probability that a hunter will hunt for small game given the added grassland in the habitat base. We used the new participation rates to estimate the number of additional small game hunters resulting from the CRP. Each additional hunter was assumed to hunt the average number of small game hunting days. Multiplying average days by new small game hunters yielded new hunting days from the existing hunter population.

Summing hunting days by new hunters and new hunting days by existing hunters provided the total new hunting days from CRP-created habitats. Sorg and Loomis summarized the hunting values in terms of the consumer surplus found in the literature, including values for small game *(31)*. These values suggested a range between $28 and $45 per day. We applied the average of these, $36.50, to the new days to estimate total net benefits of hunting from the CRP.

Estimating Benefits of Improved Habitats

Hunting data, such as the value of hunting days, are explored to determine benefits to users of improved habitats. Benefits are estimated according to changes in participation in small game hunting due to changes in habitat availability from the CRP. To determine benefits, we first had to:

- **Determine the habitat available,** which affects the hunter's decision to hunt. As used in the Walsh model, the amount of habitat available (the habitat variable) included forestland, rangeland, and pastureland in a hunter's resident State.
- **Determine rates of participation in small game hunting.** Hunter response to increases in habitat availability occurs when more of the general population participate in small game hunting (new hunters), and when existing hunters go more often for small game.
- **Find if habitat added by the CRP adds new hunters.** We estimated the new participation rate of new hunters (number of new hunters participating) and the total days of hunting by new hunters in each year of the CRP (by multiplying the average days of participation by the number of new hunters).
- **Find if habitat added by the CRP entices existing hunters to participate more.** We estimated the new participation rate of existing hunters, after predicting the probability of a hunter being a small game hunter and predicting the probability that a hunter hunts more for small game given added grassland in the habitat base for each year of the CRP. We then calculated the total days of hunting by existing hunters in each year of the CRP (by multiplying the average days of participation by the number of existing hunters).
- **Determine the total new days spent hunting for small game** from summing the number of hunting days for new and existing hunters.

Applying the value of hunting days to the number of new hunting days provided the total net benefits from hunting due to increased habitat from the CRP.

Irrigated Land Is Also Enrolled in the CRP

Producers would normally enroll their less productive, dryland acreage in the CRP. But for some irrigated cropland, economic factors and physical characteristics of aquifers may make CRP enrollment an alternative to dryland farming.

In 1984, 85 percent of irrigated acreage for crop production (39.1 million acres) was in 17 Western States, accounting for 90 percent of water used for irrigation *(39)*. About 13.8 million irrigated acres in 1983 were located in groundwater decline areas *(29)*. The greatest share of this land (67.5 percent) was in Nebraska, Kansas, Oklahoma, and Texas. Groundwater decline areas experience at least a 6-inch average annual decline in the static water level.

Why Irrigators Enrolled

Producers with low current profits, low crop price expectations, and significantly high pumping lifts with a declining static water level may view CRP enrollment as a viable economic option to dryland production. (Pumping lift, in general, refers to the depth from the level of the aquifer water table to the surface.)

The CRP bid-setting structure and/or maximum rental rates (bid caps) also encouraged enrollment of irrigated acreage in some areas. The degree to which maximum CRP rental rates reflect average cash rental rates (received for renting out land in the market) for irrigated cropland influences the level of irrigated enrollment. The bid caps in the Plains States of Kansas, Oklahoma, and Texas may have encouraged enrollment of irrigated land because average CRP rental rates were nearly equal to or greater than the 1986 average cash rents for irrigated land (table 13).

Why Irrigators Would Continue To Enroll

The differential in returns between irrigated and dryland production is expected to warrant continued irrigation for most irrigators. However, producers with marginal irrigated acreage will likely continue to enroll in the CRP. Marginal irrigated acreage is irrigated land that results in low net returns because of high energy costs (due to high pump lifts and/or low pump capacities) or low productivity.

Table 13 — CRP rental rates and average cropland cash rental values for the first five signups, by State

State	Average CRP rental rate	1986 average cash rents [1] Irrigated	Dryland	Likely irrigated acres enrolled
	Dollars per acre			Acres
Arizona	—	126	—	—
California	48	123	29	1,631
Colorado	41	63	13	16,991
Idaho	45	87	31	26,679
Kansas	52	55	27	33,781
Montana	37	53	21	764
Nebraska	55	87	43	77,332
Nevada	40	64	—	108
New Mexico	38	69	14	18,820
North Dakota	38	69	31	4,534
Oklahoma	42	39	27	7,999
Oregon	49	101	43	4,008
South Dakota	39	62	27	9,501
Texas	39	45	22	212,080
Utah	40	54	13	1,152
Washington	49	97	41	6,578
Wyoming	38	45	15	951
Total	NA	NA	NA	422,909

---- = No irrigated or dryland acreage reported for the program crop enrolled in the CRP.
NA = Not applicable.
[1] Estimates from an annual land value survey conducted by ERS.

Although Small, Enrollment of Irrigated Land Provides Economic Benefits to Remaining Irrigators

Significantly high pumping lifts, a declining static water level, low current profits, low well yields, and low crop price expectations are some reasons why producers have enrolled, and will continue to enroll, irrigated cropland in the CRP. Total enrollment of irrigated land may be small, but benefits do accrue when groundwater pumping costs are reduced.

Enrolling irrigated land in the CRP generates benefits by conserving groundwater supplies, thereby prolonging the life of aquifers. Retiring irrigated cropland reduces the amount of groundwater pumped from aquifers. Reduced pumping reduces pump lifts (for irrigators not enrolled) relative to lifts without the CRP. The resulting energy savings translate into reduced pumping costs and increases in net farm incomes. Groundwater savings today may extend the life of the aquifer, assuming no increase in area irrigated from groundwater or in water application rates. For areas facing economic exhaustion of an aquifer (where high pumping lifts increase costs and eliminate profits), extending the aquifer's life gives rural communities more time to adjust to reduced irrigated output and eases the transition to a dryland-based agricultural economy.

A Small Amount Enrolled and Likely Irrigated

Irrigated acreage enrolled in the CRP is small relative to total enrollment. We estimated that 1.8 percent of the 23 million acres of cropland enrolled in the CRP by the end of 1987 was irrigated (table 14). For the 17 Western States, 2.8 percent of the enrolled land was likely irrigated acres, while 3.9 percent of enrolled land in the Northern and Southern Plains was likely irrigated.

Most (81.6 percent) of the likely irrigated acres enrolled were from the Plains States, 83.8 percent of which were from Texas and Nebraska.

While the Plains States dominate enrollment of likely irrigated land, that share also stems from other areas having relatively few irrigated acres devoted to program crops, such as in the Pacific and Mountain States. Higher profit margins and climatic conditions in these regions allocate a larger share of groundwater to nonprogram crops (such as forage, fruit, vegetables, and nuts). In addition, a large share of feed grains in these regions is produced for onfarm use rather than as a commodity for sale.

Enrollment Would Expand, But Slightly

Assuming that irrigated land enrolls at the historical rate, approximately 698,000-852,000 irrigated acres would enroll from the 17 Western States by the end of 1990 (table 14). The largest share (82.5 percent) would enroll from the Plains States (mainly Nebraska and Texas). Irrigated acreage would account for 1.7 percent of total CRP enrollment. About 2.8 percent of CRP enrollment in the 17 Western States would be irrigated acres.

If most of the irrigated land likely to enroll already enrolled during initial CRP signups, then between 540,000 and 661,000 irrigated acres would enroll by the end of 1990 (table 14). As with the historical rate of enrollment, the largest share will be enrolled from the Plains States.

Enrollment would result in groundwater savings. Estimated annual savings in groundwater from CRP enrollment under the baseline range from 0.7 to 1.1 million acre-feet of water (table 14). Texas (Southern Plains) would realize the greatest share of these savings. The effect of cumulative groundwater savings, however, ultimately results in measurable economic benefits to society.

The estimated groundwater savings under the baseline translate into between $14.3 and $18 million of present value benefits for farmers who continue to irrigate in Texas and Nebraska (referred to as remaining irrigators). (Texas and Nebraska were the only States containing counties in groundwater decline areas and with more than 1,000 acres of cropland enrolled in the CRP. Therefore, these are the only two States assumed to realize benefits of slower reductions in groundwater supply due to CRP enrollment.) These benefits represent an increase in net farm income to remaining irrigators over 40 years, assuming a 4-percent discount rate (table 15).

The magnitude of present value benefits across the two enrollment scenarios is proportional to the quantity of groundwater saved and irrigated area enrolled, primarily because pumping costs were assumed to remain constant across scenarios. On average, savings in pumping costs over 40 years generate $40 per acre in present value benefits for Texas and Nebraska, assuming a 4-percent discount rate. However, for a given quantity of water saved, Texas incurs a greater lift effect, larger pumping cost savings, and, therefore, larger per-acre benefits (table 15).

These benefits do not include additional benefits associated with the value of extending the aquifer's life or increased efficiencies in irrigation applications over time. However, extending the life of the aquifer eases the transition to a dryland-based agricultural economy for rural areas facing economic exhaustion of groundwater supplies.

Table 14 — Groundwater savings associated with irrigated acreage in the CRP, by region

Item and region	1987	Baseline scenario: Historical enrollment	Baseline scenario: Reduced enrollment
		1,000 acres	
Irrigated area enrolled in CRP:			
Pacific	12	20-24	15-19
Mountain	66	103-127	81-997
Northern Plains	125	207-253	160-196
Southern Plains	220	348-450	284-347
Total for 17 Western States	423	698-852	540-661
		1,000 feet	
Annual groundwater savings:			
Pacific	23	50-61	37-48
Mountain	98	162-198	127-157
Northern Plains	144	231-284	179-220
Southern Plains	266	448-549	346-424
Total for 17 Western States	531	891-1,092	689-849

Table 15 — Present value of benefits from reduced pumping costs associated with irrigated land enrolled in the CRP[1]

State	Historical enrollment rate	Reduced enrollment rate
	Million dollars [2]	
Nebraska	1.27	1.00
Texas	16.81	13.32
Total	18.08	14.32
	Dollars per acre	
Nebraska	12.51	12.76
Texas	46.93	48.18
Total	39.35	40.35

[1] Benefits were estimated for 19 Nebraska counties and for 28 Texas counties.

[2] Values are expressed in 1986 dollars using a real discount rate of 4 percent and represent benefits over a 40-year period.

Method of Estimating Factors Affecting Irrigated Land in the CRP

Using a variety of models and procedures allowed us to estimate the amount of irrigated land in the CRP, the criteria for enrolling that land, the reduced energy costs for other irrigators, and the amount of irrigated land that might enroll in the CRP.

We estimated irrigated acreage enrolled in the CRP from CRP data on enrolled land. The data did not indicate whether the cropland enrolled was irrigated. We developed a way to estimate the amount, based on a comparison of expected irrigated yields and reported commodity base yields. We determined a lower-bound irrigated yield for each program crop by State based on differences between State average dryland and irrigated yields for 1984. If the farm base yield, as reported for each CRP contract, was greater than the lower-bound irrigated yield criteria, the contract acreage by crop was classified as "likely irrigated acreage."

Estimating Possible Enrollment

We estimated the potential amount of irrigated land that might be enrolled as the CRP expands to 45 million acres under two subsets of assumptions (both under the baseline scenario). One subset assumed that marginal irrigated land would continue to enroll in the CRP at the rate observed through 1987 (historical rate), and held constant the ratio of likely irrigated land in the CRP to total CRP enrollment. This potential enrollment is a maximum estimate of the enrollment of irrigated land, given that enrollment criteria and incentives remain the same. The second subset assumes that marginal irrigated land will continue to enroll, but at half the historical rate. This subset also assumes that most marginal irrigated land likely to enroll in the CRP was enrolled during the initial signups (prior to September 1987).

Estimating Probable Enrollment

Both rates of potential enrollment for the baseline scenario were based on an assumption that enrollment of irrigated land was subject to an upper bound: irrigated land used to produce program crops would not enroll unless pumping lifts exceeded 200 feet. Therefore, while 13.4 million irrigated acres in the 17 Western States are in groundwater decline areas and 12 million acres are highly erodible, only 2.5 million acres are likely to enroll (table 16). This smaller area is the land planted to program crops and irrigated with lifts with over 200 feet. An upper limit of 2.5 million acres amounts to 6.4 percent of total irrigated acreage in the 17 Western States and 12.9 percent of the total irrigated acreage in the 17 Western States that uses groundwater as the sole source of irrigation water.

Determining Benefits of Enrollment

Economic benefits from groundwater savings associated with enrolling irrigated land in the CRP occur as a result of reduced pumping costs to other irrigators and as an extension in the life of the aquifer. Reduced pumping costs reflect reduced lifts.

Benefits of extending the life of the aquifer occur because it is possible to irrigate for additional years, beyond the "normal" life of the aquifer without the CRP. Because such benefits do not occur until the distant future, we measured benefits associated only with reduced pumping costs for irrigators who do not enroll in the CRP *(3)*. We assumed that benefits would be realized only in counties in groundwater decline areas having more than 1,000 acres of cropland enrolled in the CRP by the end of 1987. Nebraska and Texas were the only States to contain such counties.

We estimated the present value of annual savings in pumping costs with a model developed by Supalla and Comer *(33)*. We assumed that annual savings would stretch over a 40-year period.

Table 16 — Constraints on the amount of irrigated cropland likely to enroll in the CRP from 17 Western States

Region	Groundwater irrigated area		All irrigated land	
	Total [1]	Program crops with lifts over 200 feet [2]	Groundwater decline areas [3]	Highly erodible [4]
		1,000 acres		
Pacific	3,857	136	2,068	1,046
Mountain	3,817	452	1,979	3,912
Northern Plains	7,369	549	4,219	2,284
Southern Plains	4,376	1,328	5,088	4,738
Total	19,419	2,465	13,354	11,980

[1] For all crops for 1984 *(40)*.
[2] Includes 1984 acreage for corn, sorghum, wheat, cotton, oats, barley, and soybeans *(40)*.
[3] As estimated by Sloggett and Dickason *(29)*.
[4] According to the 1982 National Resources Inventory database provided by Dan Colacicco, Economic Research Service, U.S. Department of Agriculture.

The CRP's Effects on Groundwater Quality Are Difficult To Quantify

The CRP may improve groundwater quality by retiring cropland that is a source of nutrients and pesticides reaching groundwater supplies *(24)*. While improvements are hard to quantify, they will occur more on regional than national levels.

Agricultural production practices are linked to groundwater quality. Cropland is often treated with chemical nutrients and pesticides to increase crop yields to more profitable levels. Under certain conditions, some chemicals can leach through the soil into groundwater supplies. At sufficiently high levels, agricultural chemicals and nutrients in groundwater can pose health threats to those depending on the aquifer for supplies of drinking water. Benefits from improved groundwater quality are gained when water-treatment costs and health risks are reduced.

CRP's Capability To Reduce Damage Is Slight

The CRP will not likely generate substantial improvements in groundwater quality, given current eligibility rules. The land eligible for the CRP has high levels of runoff of water and soil particles. But, much of the chemicals run off the surface rather than percolate through the soil profile, thereby becoming a surface water pollutant *(8)*.

The CRP probably will not significantly affect national groundwater quality. About 8.6 million acres of cropland are considered to be both eligible for CRP enrollment and vulnerable to groundwater pollution. This amount represents 13.4 percent of all cropland eligible for the CRP yet only 16.3 percent of all vulnerable cropland.

However, CRP enrollment could possibly generate noticeable improvements in groundwater quality in several regions. About 65 percent of the cropland vulnerable to groundwater pollution in the Southern Plains is eligible for CRP enrollment (ignoring the 25-percent enrollment limit). A larger share (31 percent) of vulnerable cropland in the Mountain region is also eligible for the CRP. If removed from production and enrolled in the CRP, land in these areas will have lower rates of nutrients and pesticides released into the groundwater.

Lack of Data Hinders Calculating Benefits

It was not possible to quantify the economic benefits of improved groundwater due to the CRP. Procedures and data for evaluating changes in groundwater quality have yet to be developed. The links between chemical use and groundwater quality and between groundwater quality and human health are poorly understood and difficult to establish. Also, data were not available for determining whether the specific land enrolled in the CRP will affect groundwater quality.

Method of Assessing Contaminant-Vulnerable Areas and CRP Reductions in Pollutants

The pesticide assessment, DRASTIC, helped us appraise how groundwater quality changes in response to lowered pesticide levels from potential land enrolled in the CRP. DRASTIC is an index used to rate an area's relative vulnerability to groundwater contamination, based on the area's hydrogeologic characteristics *(24)*. An area was assumed to be vulnerable to groundwater contamination if the area's DRASTIC index was greater than 150 *(24)*. The average DRASTIC score in this country is about 130.

We assessed some regional scores because scores of specific cropland already or likely to be enrolled in the CRP could not be identified. We determined the DRASTIC score and acreage of cropland eligible for the CRP for each sample of cropland in the National Resources Inventory. DRASTIC scores were then computed with a combination of site-specific data available from the inventory and other county average data that were not site-specific. We then evaluated cropland that is both eligible for the CRP and vulnerable to groundwater pollution at the regional level (table 17).

Table 17 — Concentration of eligible and vulnerable cropland, by region

Region	CRP-eligible and pesticide-vulnerable cropland a percentage of: All eligible cropland	All vulnerable cropland
	Percent	
Appalachian	44.4	21.6
Corn Belt	4.8	8.7
Delta	55.2	11.9
Lake States	21.9	9.1
Mountain	5.3	31.3
Northeast	19.6	12.0
Northern Plains	3.5	13.7
Pacific	9.2	10.3
Southeast	41.4	10.9
Southern Plains	19.3	65.1
U.S. average	13.4	16.3

CRP Enrollment Improves Natural Resources and Generates Economic Benefits From Those Improvements

The benefits of improved natural resources from the CRP are large, especially in the most populous areas with the greatest demand for such resources. Lessons learned could be used in developing other programs for improving natural resources.

The CRP generates large total and per-acre benefits under all regional scenarios of enrollment. But the benefits vary among areas because population, levels of damage, and the demand for resources vary.

CRP Provides Benefits Under All Three Enrollment Scenarios

The CRP generates about $10 billion (present value) in benefits to natural resources under the baseline scenario (table 18). The largest share of benefits is from improved wildlife habitat (40 percent), followed closely by improved surface water quality (37 percent). Benefits from improved soil productivity and air quality and increased groundwater supplies are much smaller.

The alternative enrollment scenarios have higher benefits. Benefits from improved air quality and increased groundwater supplies remain constant for the alternative scenarios, with all increases coming from improved wildlife habitats and water quality. This distribution of benefits occurs because additional CRP land enrolled in the forestry and environmental scenarios comes mainly from east of the Mississippi River. (Wind erosion and groundwater supply problems occur primarily west of the Mississippi.) Overall benefits increase by 7.8 percent in the environmental scenario and 12.6 percent in the forestry scenario.

Benefits to users of natural resources vary widely among regions (table 19). The Lake States realize the greatest benefits in the baseline and forestry scenarios, and the Corn Belt receives the greatest benefits in the environmental scenario.

The regional benefits also vary among scenarios. Benefits in the Appalachian, Delta, Lake States, and Southeast regions are higher in the forestry scenario than in the baseline. But benefits decrease in other regions in the forestry scenario, because CRP enrollment shifts toward regions more likely to plant trees on enrolled land. Benefits in the environmental scenario are greater than in the baseline in the Corn Belt, Delta, and Northeast, because these regions have the greatest amount of cropland deemed environmentally sensitive. The Delta was the only region with increased benefits from enrollment under both alternative scenarios.

Per-Acre Benefits Follow Demand for Resources

Benefits per acre of land enrolled in the CRP reveal relationships that may help other land retirement programs target land to increase benefits to natural resources (table 20). Shifting cropland enrollment from regions with low benefits per acre to regions with high benefits per acre would increase gross benefits from the program. Net benefits (benefits after costs are deducted) would also increase, but only if the rental rates were similar across regions. Per-acre benefits differ among regions due to differences in erosion rates, types of erosion, natural resources, and demand for those resources.

The demand for resources must be a consideration in designing enrollment criteria if economic benefits are a major goal of land retirement programs. The largest per-acre benefits from CRP enrollment generally are seen in regions where population, and thus the demand for resources, are highest. Benefits from improved air quality, water quality, recreation, and wildlife habitat depend on demands for these resources by households or industry. Only benefits from improved soil productivity are linked strictly to the amount of agricultural land enrolled. The Northeast and Lake States have large populations and large concentrations of industry, and thereby place large demands on water and recreation resources. These two regions received the highest benefits per-acre in all scenarios. On the other hand, regions that are largely agricultural or sparsely populated, such as the Mountain and Northern Plains, received the lowest per-acre benefits in all three scenarios, even though the physical improvements in the quality of resources may be just as great or greater.

Table 18 — Summary of benefits to natural resources if the CRP is completed at 40-45 million acres by 1990

Resource	Baseline		Forestry		Environmental	
	Best [1]	Range	Best [1]	Range	Best [1]	Range
			Billion dollars			
Productivity	1.63	0.82-2.44	1.58	0.79-2.37	1.50	0.75-2.25
Water quality	3.56	1.88-5.28	4.11	2.22-6.06	4.03	2.16-5.96
Air quality	.55	.39-1.11	.55	.39-1.11	.55	.39-1.11
Wildlife	3.85	2.95-4.75	4.98	3.82-6.14	4.51	3.46-5.56
Groundwater supply	.02	.01-.02	.02	.01-.02	.02	.01-.02
Total	9.61	6.05-13.59	11.24	7.23-15.70	10.61	6.77-14.90

[1] Benefits deemed most likely.

Table 19 — Summary of benefits from improved natural resources due to CRP enrollment, by region

Region	Baseline		Forestry		Environmental	
	Best [1]	Range	Best [1]	Range	Best [1]	Range
			Billion dollars			
Appalachian	0.84	0.46-1.22	0.99	0.56-1.42	0.78	0.43-1.14
Corn Belt	1.90	1.16-2.65	1.61	.97-2.24	2.36	1.44-3.28
Delta	.67	.44-.90	1.11	.74-1.5	1.29	.86-1.73
Lake States	2.10	1.48-2.75	3.38	2.36-4.39	2.11	1.48-2.73
Mountain	.85	.49-1.36	.77	.44-1.25	.78	.45-1.27
Northeast	.53	.38-.69	.42	.30-.54	.85	.61-1.09
Northern Plains	.78	.46-1.22	.70	.42-1.12	.67	.40-1.07
Pacific	.39	.22-.59	.34	.21-.52	.38	.23-.59
Southeast	.70	.48-.93	1.17	.80-1.56	.64	.44-.86
Southern Plains	.85	.48-1.28	.75	.43-1.16	.75	.43-1.14
Total	9.61	6.05-13.59	11.24	7.23-15.70	10.61	6.77-14.90

[1] Benefits deemed most likely.

Table 20 — Per-acre benefits from improved natural resources due to CRP enrollment, by region

Region	Baseline		Forestry		Environmental	
	Best [1]	Range	Best [1]	Range	Best [1]	Range
			Dollars			
Appalachian	426	234-619	388	220-557	416	229-608
Corn Belt	249	152-346	250	151-348	235	143-327
Delta	464	308-629	486	324-657	463	309-621
Lake States	558	390-726	507	354-658	546	383-706
Mountain	100	58-161	108	62-176	104	60-170
Northeast	727	520-845	681	486-876	763	548-978
Northern Plains	80	48-127	86	52-138	85	51-136
Pacific	145	83-223	152	94-233	145	88-225
Southeast	367	253-489	353	241-471	361	248-485
Southern Plains	125	71-189	132	75-204	135	77-205
U.S. average	214	134-302	250	161-349	236	150-331

[1] Benefits deemed most likely.

The CRP Serves as a Model for Future Conservation Programs

Although the data are not all-inclusive and the findings should be treated with caution, the results are strong enough for many implications to be made. The most significant is that conservation programs like the CRP, regardless of area targeted for retirement, can fulfill both agricultural and environmental goals.

Results of the regional scenarios have implications for public policies where distribution of benefits is a concern. The magnitude and distribution of the benefits can be altered by changing the emphasis of the program, as seen in the enrollment scenarios. Changes in program emphasis will redistribute benefits among regions. Those regions standing to lose benefits (and not just direct program payments) because of changing goals would likely resist change and may exert pressure to maintain the status quo.

A Caution About the Findings

It is important to look at the ranges of estimates reported and not rely solely on the "best" estimates, which are benefits deemed most likely. All benefits reported are a best approximation, given the data available. It is not possible to corroborate our findings with other published results, because there are so few estimates available on benefits to natural resources from national soil conservation programs. Of course, improved data would reduce the number of assumptions needed to estimate benefits and would improve the accuracy of the estimates.

The estimates are incomplete because they do not include all benefits to all natural resources. For example, benefits of improved water quality to commercial fisheries, swimming, and boating were not included. Benefits of improved wildlife habitats to nonconsumptive users and to large game and waterfowl hunters were not estimated, nor were benefits of improved groundwater quality. Some of these benefits are likely to be large.

The estimated benefits also depend on the CRP successfully enrolling 45 million acres of land. This goal may not be achieved. Total benefits would, therefore, be less than reported here, although the benefits per acre may be the same.

Whether the total benefits of the CRP are commensurate with its costs depend not only on the extent of the resource/environmental benefits but also on the national income gains and losses placed on farm income, timber production, consumer costs, and real program administrative costs *(45)*.

The CRP Can Provide Lessons for Other Programs

Alternative conservation programs may be more economically efficient than the CRP in achieving goals for natural resources. For example, similar improvements in natural resources could possibly be achieved at lower cost through other means, such as employing soil conservation practices on more land; developing and deploying best management practices; adopting low-input, sustainable agricultural practices; reducing Government incentives to produce; or purchasing environmentally sensitive land and placing it in a permanent soil bank.

The CRP demonstrates that commodity and set-aside programs can provide incentives for producers to protect natural resources. At the very least, lessons learned from the CRP can be used in the design of future Federal and State programs for linking agricultural and environmental policy.

References

(1) Alt, K., C.T. Osborn, and D. Colacicco. *Soil Erosion: What Effect on Agricultural Productivity?* AIB-556. U.S. Dept. Agr., Econ. Res. Serv., Jan. 1989.

(2) Benson, J., and C. Napier. "Wind Damage in Great Plains More Than Double Last Year's," News bulletin. U.S. Dept. Agr., Office of Inf., News Div. June 1984.

(3) Bleed, A., N. Gollehon, D. Razavian, and R.J. Supalla. *Economic, Environmental and Financing Optimization Analysis of Platte River Development Alternatives.* Nebraska Water Resources Center, Conserv. and Surv. Div., Inst. Agr. and Nat. Resour., Univ. of Nebraska--Lincoln, 1979.

(4) Brady, S.J., and R.E. Warner. "The Relationship Between Farmland Wildlife, Land Use, and Erosion and Sediment Control Goals in Illinois," Unpublished working paper. 1984.

(5) Clark, E.H., II, J.A. Haverkamp, and W. Chapman. *Eroding Soils: The Off-Farm Impacts.* Washington, DC: The Conservation Foundation, 1985.

(6) Crosson, P.R. "Soil Erosion and Policy Issues," *Agriculture and the Environment.* T.T. Phipps, P.R. Crosson, and K.A. Price, eds. Washington, DC: Resources for the Future, 1986.

(7) Crowder, B.M. "Economic Costs of Reservoir Sedimentation: A Regional Approach to Estimating Cropland Erosion Damage," *Journal of Soil and Water Conservation*, Vol. 42, No. 3 (1987), pp. 194-97.

(8) Crowder, B.M., and C.E. Young. *Managing Farm Nutrient Tradeoffs For Surface and Ground-Water Quality*, AER-583. U.S. Dept. Agr., Econ. Res. Serv., Jan. 1988.

(9) Cutler, M.R. "Integrating Wildlife Habitat Features in Agricultural Programs," *Transactions North American Wildlife and Natural Resources Conference 49*, 1984, pp. 132-40.

(10) Dicks, M. "Conservation Reserve Program Baseline Projections," Unpublished working paper. U.S. Dept. Agr., Econ. Res. Serv., 1987.

(11) Edwards, W.R., R.E. Warner, S.P. Havera, R.F. Labisky, and J.A. Ellis. "The Abundance of Cottontails in Relation to Agricultural Land Use in Illinois (U.S.A.) 1956-1978, with Comments on Mechanism of Regulation," *Proceedings of the World Lagomorph Conference, August 12-16, 1979.* K. Myers and C.D. MacInnes, eds. Univ. of Guelph--Ontario, Canada, 1979.

(12) Farris, A.L., and S.H. Cole. "Strategies and Costs for Wildlife Habitat Restoration on Agricultural Lands," *Transactions North American Wildlife and Natural Resource Conference 46*, 1981, pp. 130-36.

(13) Freeman, A.M., III. *The Benefits of Environmental Improvement.* Baltimore, MD: Johns Hopkins University Press, 1979.

(14) Fryrear, D.W. "Dust Storms in the Southern Great Plains," *Transactions of the ASAE*, Vol. 24, No. 4 (1981), pp. 991-94.

(15) Gianessi, L.P., H.M. Peskin, and C. Puffer. *A National Data Base of Nonurban Nonpoint Source Discharges and Their Effect on the Nation's Water Quality.* Washington, DC: Resources for the Future, 1985.

(16) Graber, J., and R. Graber. *Declining Grassland Birds*, Illinois Natural History Survey Report 227. 1983.

(17) Hagen, L.J., and N.P. Woodruff. "Air Pollution From Duststorms in the Great Plains," *Atmospheric Environment*, Vol. 7 (1973), pp. 323-32.

(18) Holmes, T.P. "The Offsite Impact of Soil Erosion on the Water Treatment Industry," *Land Economics*, Vol. 64, No. 4 (1988), pp. 356-66.

(19) Huszar, P.C., and S.L. Piper. "Estimating the Off-Site Costs of Wind Erosion in New Mexico," *Journal of Soil and Water Conservation*, Vol. 41, No. 6 (1986), pp. 414-16.

(20) Judy, R.D., Jr., P.N. Seeley, T.M. Murray, S.C. Svirsky, M.R. Whitworth, and L.S. Ischinger. *1982 National Fisheries Survey, Vol. I, Technical Report: Initial Findings*, FWS/OBS-84/06. U.S. Dept. Int., Fish and Wildl. Serv., 1984.

(21) Jutze, G., and K. Axetell. *Investigation of Fugitive Dust: Volume 11--Control Strategy and Regulatory Approach*, EPA-450/3-74-036b. U.S. Envirn. Protect. Agency, Research Triangle Park, NC, 1974.

(22) Loomis, J., and C. Sorg. *A Critical Summary of Empirical Estimates of the Value of Wildlife, Wilderness, and General Recreation Related to National Forest Regions*, Contract Report No. 40-82-FT-2-714. U.S. Dept. Agr., Forest Serv., Rocky Mountain Forest and Range Exp. Station, Ft. Collins, CO, 1983.

(23) Miller, J.R., and M.J. Hay. "Determinants of Hunter Participation: Duck Hunting in the Mississippi Flyway," *American Journal of Agricultural Economics*, Vol. 63, No. 4 (1981), pp. 677-84.

(24) Nielsen, E.G., and L.K. Lee. *The Magnitude and Costs of Groundwater Contamination From Agricultural Chemicals: A National Perspective*, AER-576. U.S. Dept. Agr., Econ. Res. Serv., Sept. 1987.

(25) Piper, S.L. "Measuring the Particulate Pollution Damages From Wind Erosion in the Western United States," *Journal of Soil and Water Conservation*, (forthcoming).

(26) Record, F.A., and L.A. Baci. *Evaluation of Contribution of Wind Blown Dust from the Desert to Levels of Particulate Matter in Desert Communities*, EPA-450/2-80-078. U.S. Envirn. Protect. Agency, Research Triangle Park, NC, 1980.

(27) Ribaudo, M.O. *Offsite Water Quality Benefits from the Conservation Reserve Program*, AER-606. U.S. Dept. Agr., Econ. Res. Serv., Feb. 1989.

(28) Salathe, L.E., J.M. Price, and K.E. Gadson. "The Food Agricultural Policy Simulator," *Agr. Econ. Res.*, Vol. 34, No. 2 (1982), pp. 1-5.

(29) Sloggett, G., and C. Dickason. *Ground-Water Mining in the United States*, AER-555. U.S. Dept. Agr., Econ. Res. Serv., Aug. 1986.

(30) Smith, R.A., R.B. Alexander, and M.G. Wolman. "Water Quality Trends in the Nation's Rivers," *Science*, Vol. 235 (1985), pp. 1,607-15.

(31) Sorg, C.F., and J.B. Loomis. *Empirical Estimates of Amenity Forest Values: A Comparative Review*, General Technical Report RM-107. U.S. Dept. Agr., Forest Serv., 1984.

(32) Strohbehn, R. *An Economic Analysis of USDA Erosion Control Programs: A New Perspective*, AER-560. U.S. Dept. Agr., Econ. Res. Serv., Aug. 1986.

(33) Supalla, R.J., and D.A. Comer. "The Economic Value of Ground Water Recharge for Irrigation Use," *Water Resources Bulletin*, Vol. 18, No. 4 (1982), pp. 679-86.

(34) Taylor, M.W., C.W. Wolfe, and W.L. Baxter. "Land-Use Change and Ring-Necked Pheasants in Nebraska," *Wildlife Society Bulletin*, Vol. 6, No. 4 (1987), pp. 226-30.

(35) U.S. Department of Agriculture. "The Second RCA Appraisal: Soil, Water, and Related Resources on Nonfederal Land in the United States, Analysis of Condition and Trends," Review draft, 1987.

(36) U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service. "Conservation Reserve Program; Interim Rule," *Federal Register*, 7 CFR 704, Issue 51, No. 49 (1986), pp. 8,780-87.

(37) U.S. Department of Agriculture, Soil Conservation Service. *1982 National Resources Inventory*. 1984.

(38) U.S. Department of Commerce, Bureau of the Census. *1978 Census of Agriculture: Irrigation*. 1981.

(39) U.S. Department of Commerce, Bureau of the Census. *1984 Farm and Ranch Irrigation Survey*, Special Report Series AG84-SR-1. 1986.

(40) U.S. Department of Commerce, Bureau of the Census. *1984 Farm and Ranch Irrigation Survey*, Special tabulations prepared for the Economic Research Service, 1987.

(41) U.S. Environmental Protection Agency, Water Planning Division. *Report to Congress: Nonpoint Sources in the U.S.* 1984.

(42) Walsh, R.G., D.A. Harpman, K.H. John, J.R. McKean, and L. LeCroy. *Wildlife and Fish Use Assessment: Long-Run Forecasts of Participation in Fishing, Hunting, and Nonconsumptive Wildlife Recreation,* Technical Report 50. Colorado State Univ.—Ft. Collins, 1987.

(43) Warner, R.E., and S.L. Etter. "Farm Conservation Measures to Benefit Wildlife, Especially Pheasant Populations," *Transactions North American Wildlife and Resources Conference 50.* 1987, pp. 135-41.

(44) Williams, J.R., J.W. Putman, and P.T. Dyke. "Assessing the Effect of Soil Erosion on Productivity with EPIC," *Erosion and Soil Productivity,* ASAE pub. 8-85. American Society of Agricultural Engineers, St. Joseph, MO, 1985.

(45) Young, C.E., and T. Osborn. *The Conservation Reserve Program: An Economic Assessment,* AER-626. U.S. Dept. Agr., Econ. Res. Serv., forthcoming.

(46) Zison, S.W., K.F. Haven, and W.B. Mills. *Water Quality Assessment: A Screening Method for Nondesignated 208 Areas.,* EPA-600/9-77-023. U.S. Envirn. Protect. Agency, Athens, GA, 1977.

Updating the Estimates To Account for Recent Changes

Some changes in CRP enrollment have occurred since the time of this analysis. The pattern of enrollment after the seventh signup and the rule changes allowing buffers may indicate that the projected natural resource benefits are too high or too low.

At the time of this analysis, 23 million acres of cropland had been enrolled in the CRP in five signups. There have now been eight signups, with about 30.6 million acres enrolled nationwide (app. table 1).

Some rules have changed, a very important change from an environmental standpoint being the decision to allow cropland in the CRP if the land is to be planted as a filter strip along a stream, lake, or estuary. Filter (sometimes called buffer) strips are land areas 66- to 99-feet wide and adjacent to streams and permanent bodies of water 5 acres or larger, and will be eligible for the CRP regardless of the class of land or erosion rate. About 40,000 acres have been enrolled as filter strips as of the eighth signup.

Another important change for the eighth signup is the inclusion of wetlands and farmed wetlands in land eligible for the CRP. These lands will affect water quality and wildlife habitats.

Enrollment after the eighth signup generally follows the baseline pattern. The eastern regions (Corn Belt, Appalachian, and Northeast) show less enrollment than might be expected, given the assumptions underlying the baseline. The western regions (Mountain, Northern Plains, and Southern Plains) show higher enrollment.

Part of the deviation is due to changes in eligibility rules after the fifth signup. But, there are no general indications that the baseline scenario is a poor projection of what the final enrollment pattern will be. The baseline assumed that enrollment rates would decrease in western regions and would increase in the Corn Belt and other regions in the East over time because of limits on enrollment. Given the estimation procedures, benefits will probably fall within the ranges reported.

Adding buffer strips may significantly increase the benefits of improved water quality due to the CRP. An acre of buffer strips has the potential to generate much greater water-quality improvements than would converting an acre of upland cropland to grassland. About 30,000 acres of buffer strips have been enrolled in the program during the sixth and seventh signups. Assuming that the proportion of land in filter strips remains constant for the remaining signups, about 90,000 acres of CRP land will be devoted to buffer strips. It was estimated that buffer strips would add between $90 and $250 million (present value) to the water-quality benefits of the CRP.

Adding wetlands to the CRP could improve local water quality and could increase hunting opportunities, thereby generating additional hunting and water-quality benefits.

Appendix table 1 — Enrollment of cropland in the CRP as of the eighth signup, by region

Region	Eighth signup		Baseline	
	Million acres	*Percent*	*Million acres*	*Percent*
Appalachian	1.00	3.27	1.97	4.38
Corn Belt	4.30	14.06	7.65	17.00
Delta	.95	3.11	1.43	3.18
Lake States	2.40	7.85	3.79	8.42
Mountain	5.97	19.53	8.47	18.82
Northeast	.18	.59	.73	1.62
Northern Plains	7.96	26.04	9.63	21.40
Pacific	1.58	5.17	2.65	5.89
Southeast	1.48	4.84	1.90	4.23
Southern Plains	4.75	15.54	6.78	15.06
Total	30.57	100.00	45.00	100.00

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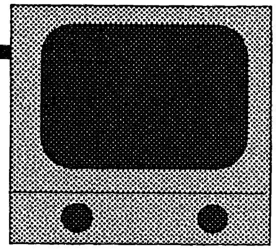

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