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AN ECONOMIC ASSESSMENT OF CRP-LIKE WATER QUALITY OPTIONS FOR THE 1990 FARM BILL

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Agricultural production inevitably results in some transmission of sediment and agricultural chemicals into surface and ground water. While low concentrations of these substances may be harmless, there is growing awareness and concern about the effects of higher concentrations and the role that agricultural policy plays in influencing water quality. With another omnibus five-year farm bill at hand, programs to protect water quality from agricultural pollution will be considered for legislation. This paper investigates two potential 1990 Farm Bill environmental options; one for protecting surface water quality and the other directed at safeguarding ground water resources. Specifically, cropland retirement programs, similar in concept to the Conservation Reserve Program of the 1985 Farm Bill, are assessed, including their benefits and costs.

Scope of Problem-Surface Water Quality

Agricultural nonpoint-source pollution reaches waterways primarily through runoff from cropland, pastureland, barnyards, and feedlots. Residuals that reach surface and ground water include sediment, nutrients (including nitrates), pesticides, bacteria, and dissolved solids such as calcium, magnesium, and other salts. Cropland's impact on surface water is widespread. Recent assessments indicated that 43 states have at least some surface waters not supporting designated uses because of agricultural residuals (EPA, 1984). The extent of the problem can be defined in terms of ambient water quality, and in terms of economic impacts.

The major surface water pollutants from cropland include suspended sediment, nitrogen, and phosphorus. Water quality monitoring data for 1982 and 1983 from U.S. Geological Survey's NASQUAN water quality monitoring system indicated that there were 30 Aggregated Sub-areas (large river basins) with average concentrations of total suspended solids (TSS) greater than 200 mg/l, a concentration at which may harm aquatic organisms. Twenty-nine ASA's had phosphorus concentrations greater than .2 mg/l, and 10 had nitrogen concentrations greater than 2 mg/l. These are the threshold concentrations at which eutrophication of water systems becomes a concern (Zison, Haven, and Mills).

Even though agriculture is a major source of these pollutants, it is not the only source. Others include sediment from forests and construction sites, and nutrients from city streets and municipal sewage treatment plants.

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Annual loadings of suspended solids, nitrogen, and phosphorus from cropland and other sources were estimated with data from Resources for the Future's Pollutant Discharge Inventory (Gianessi, Peskin, and Puffer). Taking these other sources into account, we identified the regions were agriculture appears to be the primary cause of above-threshold concentrations. These regions, identified in figure 1, are concentrated in parts of the Corn Belt, Lake States, and Northern and Southern Plains. While most regions have at least a local problem of impaired water use because of cropland runoff, the regions indicated on the map have the most widespread problems.

With respect to economic damages, however, the location of the problem shifts. Damages are not only a function of ambient concentrations (discharges), but also of the demand for water resources. Regions with large populations and concentrations of industry would place greater demands on water resources than more sparsely populated regions. Equal levels of pollution will tend to impose greater costs on water users in regions where demand for water is greater.

Sediment from all erosion sources may be causing as much as $5-$15 billion in offsite damages to surface water each year (Ribaudo 1989). These damages include those to recreation, commercial fishing, municipal and industrial water use, roadside ditches, irrigation canals, navigation, and water treatment facilities, and from increased flooding due to stream bed sedimentation. About one third of these damages can be attributed to sediment eroding from cropland. Additional costs are imposed by dissolved nutrients, pesticides, salts, and bacteria.

Even though the level of erosion in the Northeast is lower than most other regions, the high demand for water resources results in greater damage for each ton of erosion. Conversely, the Corn Belt has a much greater level of erosion, but a lower demand for water resources. As a result, per ton damages are much lower. Since there is no reason to expect that the greatest per-acre erosion conditions are correlated with the greatest demand for water quality, any program aimed at maximizing water quality benefits from reducing erosion would have to take into account both the level of erosion and the demand for water resources.

Scope of Problem - Ground Water Quality

Pesticides and nitrates applied to cropland can reach ground water by leaching through the soil. If these materials reach an aquifer, they can pose a risk to those who rely on the water for drinking supplies. Also, where ground water is the source of base flow for streams, contaminants in the ground water cause problems for surface water users as well.

Over 97 percent of rural Americans and nearly half of the total population rely on ground water for drinking and household uses (Nielsen and Lee). The potential for contamination of ground water supplies is increasing as farm production is intensified and chemicals are substituted for agricultural land and labor. Reliance on ground water, difficulty and cost of cleanup once contamination occurs, and interaction between ground and surface waters suggest a need to protect existing ground water quality.

The potential health risks associated with pesticides and other pollutants in ground water and the involuntary exposure of people to these compounds have forced government officials at all levels to address liability questions. But, due to the difficulty of identifying the source of chemicals found in ground water, uncertainty in assigning liability for ground water contamination complicates efforts to control or reduce the effects of agricultural applications of chemicals.

Comprehensive data on pesticide levels in ground water do not yet exist. Nitrate monitoring responsibilities are split among Federal, State, and local water-quality and health agencies, with little data coordination among them. EPA is conducting a national survey of pesticides in drinking water from ground water sources, with results expected in about a year. More than 40 agricultural pesticides, which in high enough concentrations can pose significant human health threats and are known to leach into ground water, are being investigated. EPA's results will help determine whether the toxicity and leaching ability of any of the surveyed pesticides warrants restrictions on their use.

The lack of data on the quality of ground water, and on the physical linkages between agricultural production and ground water quality, makes the scope of the ground water problem difficult to assess. However, it was possible to identify regions where agriculture is likely to have an effect on ground water quality.

The potential for fertilizers and pesticides to accumulate in ground water depends on a combination of environmental and human factors. In general, areas where chemical leaching may present a risk to ground water have sandy, highly permeable soils low in organic matter, receive enough rainfall or irrigation to promote deep leaching, and are located over shallow, unconfined aquifers. A composite measurement, called the DRASTIC Index (Aller et al., 1985), uses these and several other hydrogeologic features to estimate the potential for nutrients and chemicals to leach to ground water. The higher the DRASTIC Index, the easier it is for water and associated dissolved chemicals to percolate through the soil profile and reach ground water. A DRASTIC Index score was calculated for National Resource Inventory sample points by combining data on soil texture and slope for each sample point with county-level values for the remaining hydrogeologic factors.

In addition to hydrogeologic conditions, the potential for chemicals to reach the ground water is also strongly influenced by the history of fertilizer and pesticide use on the farm and the chemical properties of the materials applied (such as persistence in soil and the tendency to adsorb onto soil particles). This is particularly important for pesticides. Each pesticide considered in this analysis was evaluated for its potential to leach to ground water with an index proposed by Gustafson (1989). In the case of nitrates, the application of nitrogen fertilizers represents just one of many possible sources of nitrates in ground water. Since the source of nitrates detected in ground water is difficult to determine, and the relative contribution from agricultural or nonagricultural sources unknown, leaching potential for nitrates as calculated in the model reflects only the quantity of nitrogen fertilizer used. Information on the extent and intensity of pesticide and nitrogen fertilizer use was obtained from information collected by USDA's Economic Research Service Objective Yield Survey and Farm Cost and Returns Survey, and a national pesticide usage data base compiled by Resources for the Future (Gianessi et al, 1988). Combining the information on vulnerability, as provided by the DRASTIC Index, with estimates on the use and leachibility of farm chemicals gives a clearer indication of areas where ground water may be at risk. The regions we estimated to be vulnerable to ground water contamination, shown in figure 2, are concentrated primarily in the Northeast, Lake States, Corn Belt, and along the lower Mississippi river.

Ground water and surface water problems do overlap somewhat, at least from a general regional viewpoint. Especially in the Northeast, critical ground water counties are also located where surface water damages per acre of cropland are highest. There is also some coincidence along the Mississippi and in the Lake States. However, it should be stressed that at the field level, coincidence of problems may not be high. In fact, fields with high erosion rates and large contributions of residuals to surface water would be expected to have the least likelihood of contributing to ground water contamination.

Land Retirement Options: The Conservation Reserve Program Model

Title XII of the 1985 Food Security Act authorized the Conservation Reserve Program, a long-term 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 was to remove from production 40-45 million acres of highly erodible cropland by 1990, and placing that land in grass or trees for a contract period of 10 years. Participating operators receive half the cost of establishing permanent cover (usually grass or trees)s and yearly rental payments over the contract period to offset income lost from not producing crops on the enrolled land.

The CRP was established with multiple goals, one of which was to improve surface water quality. The CRP was to achieve its goals by targeting "highly erodible" cropland. Because wind erosion was included in the eligibility criteria, a large amount of land not significantly contributing to a water quality problem was included in the program. Even though total water quality benefits from the program were estimated to range between $1.8 and $5.5 billion (Young and Osborn, 1990), they could have been higher if the eligibility criteria had emphasized sheet and rill erosion, or if USDA rental payments had been used to encourage enrollment in areas subject to agricultural water pollution. Benefits could have been increased still further if potential water quality benefits (demand for water resources) had also been incorporated into the eligibility requirements. Because of the perceived success of the CRP, a similar program aimed at surface water quality has been discussed for the 1990 Farm Bill.

Ground water protection was not one of the goals of the CRP. However, the potential for using a program such as the CRP to retire cropland above particularly sensitive aquifers or well recharge areas is evident. Proposals for such a program have also surfaced during early 1990 Farm Bill discussions. In what follows, two 10 million acre land retirement options based on the CRP model are considered. One is aimed at surface water quality protection while the other is aimed at safeguarding ground water quality.

Targeting Cropland for Retirement-Surface Water Quality

A CRP-like program targeted to surface water quality could have any of several goals. These include maximizing economic benefits to water users, minimizing government costs for reaching an acreage goal, or finding the most cost-effective way of improving ambient water quality. We chose to investigate a program designed to maximize water quality benefits to water users. The program consisted of the 10 million acres of cropland above current CRP enrollment which would generate the greatest water quality benefits when retired. The size of the program is the maximum believed to be acceptable for inclusion in the Farm Bill. Our results can also be used to make inferences about smaller programs.

Ten million acres were selected from all cropland identified in the 1982 National Resources Inventory, minus that acreage assumed to be enrolled in the CRP after the 7th sign-up. Although NRI points enrolled in the CRP cannot be determined with certainty, it is possible to identify points with the same geographic and physical characteristics as the land enrolled in the CRP. Because this cropland is already retired from production, it was assumed to be ineligible for the water quality program under consideration.

A proxy for potential water quality benefits from retirement were estimated for each NRI point (270,000 in all). For each point, the per acre reduction in sheet and rill erosion from retiring the cropland and planting grass was calculated. This change in erosion was then multiplied by the water quality damages per ton of erosion estimated by Ribaudo for the relevant USDA Farm Production Region (FPR). The result is a proxy for the potential benefits per acre from retiring the land represented by that point. Actual benefits may differ because the relationship between erosion and water quality damages is not necessarily linear. The NRI points were then ranked by potential benefits per acre, and the top 10 million acres selected. Figure 3 shows the location of this land.

Acreage is concentrated in the Northeast, Corn Belt, and Lake States (table 1). Most States have at least some acreage identified. Annual sheet and rill erosion on this land was estimated to be reduced by 333 million tons (33 tons/acre/year average), or about 18 percent of cropland erosion reported in the 1982 NRI. The percentage reduction of sheet and rill on cropland is even higher when one considers the 34 million acres of highly erodible cropland already in the CRP.

One of the results of including economic measures in the targeting criteria is that land not defined as highly erodible can be included. In areas with highly valued water, such as the Northeast, land eroding at relatively moderate levels was included in the program, while land eroding at much higher levels in a region such as the Corn Belt or Northern Plains was not targeted (table 1).

The reduction in erosion and associated discharge of sediment and chemicals into waterways was estimated to generate between $236 and $891 million in benefits to surface water users each year the 10 million acres is out of production(in 1986 $) (table 1). Total benefits over the life of the program would total $2.4-$8.9 billion (undiscounted). Benefits are defined as change in consumer surplus for recreational fishing, change in producer surplus for municipal water treatment and industrial uses, and changes in defensive expenditures for roadside and irrigation ditches, navigation, and reservoir sedimentation. The water quality benefits were estimated with the procedures described in Ribaudo (1989). The greatest benefits are seen in the Pacific and Northeast regions.

Given assumed, acceptable rental rates paid over a 10-year contract life and 50-percent Government cost-share for cover establishment, gross program costs for a 10 million acres program would be about $9.5 billion. Rental rates were estimated from yield and price data and the costs of establishing CRP conservation covers. The Government cost is not a true cost in a social accounting sense, but is nevertheless extremely relevant to Government decision makers.

Retiring 10 million acres of cropland for the water quality program, on top of the cropland already retired under the CRP, was found to generate changes in the prices of agricultural commodities. The effects of the CRP on crop production and prices were simulated using the Food and Agricultural Policy Simulator (FAPSIM). FAPSIM is an annual econometric model of the U.S. agricultural sector. FAPSIM estimates a simultaneous price-quantity equilibrium solution for a set of individual commodity models developed for corn, oats, barely, grain sorghum, wheat, soybeans, and cotton beef, pork, dairy, chickens, eggs, and turkeys (Salathe, Price, and Gadson). Table 2 shows how many of the 10 million acres were in each major program crop. The FAPSIM model indicated that the long-term equilibrium price of corn would increase 19 percent, the price of soybeans by 12 percent, and the price of wheat by 9 percent. Such price increases would impose costs on consumers, in the form or reduced consumer surplus. These estimates were made under the assumptions that there would be no downward adjustment of ARP levels as acreage is retired, and that for every acre retired, approximately 0.2 acres would enter production from other sources (program slippage).

An increase in commodity prices would reduce government outlays for deficiency payments. CCC deficiency payment savings were estimated to be $2.9 billion per year after all acres are retired. Assuming 10-year contracts and enrollment of 2 million acres per year during 1991-1995, total deficiency payment savings over the life of the program could be $29 billion.

However, it is likely that ARP levels would be relaxed if a significant amount of corn acreage was retired in this program. This would moderate crop price increases and would lessen deficiency payment savings. If ARP levels were relaxed sufficiently to maintain the level of production projected in the "no-water quality program" Baseline, there would be no change in the price of program commodities. Consequently the crop price impacts and deficiency payment savings estimates may significantly overstate the true effects of a 10 million acre water quality program.

The removal of cropland from production, while aimed primarily at surface water quality, also addresses ground water concerns. Reduced pesticide and fertilizer use on the 10 million acres identified for the surface water quality program implies reduced loadings to ground water, and reduced risk of contamination. Nutrient fertilizer use was estimated to decrease about 4 percent nationally. Fertilizer use would decrease by about 47 percent in the Northeast. Pesticide leaching potential would be reduced by about 6 percent nationally, and about 48 percent in the Northeast. The impacts in the Northeast are large because a large share of the surface water quality program was targeted to the Northeast. The 2.6 million acres of cropland targeted in the Northeast represents about 17 percent of all cropland acreage in the region, and a much larger share of cropland in crops that are heavy users of chemicals (namely corn).

Targeting Cropland for Retirement-Ground Water Quality

Ground water quality protection could also be the goal of a cropland retirement program. Ten million acres for inclusion in a ground water protection program were selected from among the counties having high DRASTIC scores and a high leaching potential for pesticides or nitrates. These counties were ranked by the number of individuals who rely on drinking water from ground water sources. The top counties with a combined total to 10 million acres of cropland were selected. 58 counties were identified in 10 states. The largest concentrations of targeted counties are around the Great Lakes (in Minnesota, Wisconsin, Illinois, Indiana, and Michigan), and in the Atlantic Coastal Plain region of North Carolina and South Carolina. Table 2 outlines geographic differences between cropland targeted for a surface water quality program and the ground water quality program. Table 3 makes a similar comparison across major commodities. The ground water program places more emphasis on cropland in the Lake States and Southeast and less in the Northeast than the surface water program.

Implications about the location of the optimal 10 million acres for a ground water program must be drawn carefully. Since the selection was based on county average data, the amount of cropland actually vulnerable in each county is probably less. At the extreme, the targeted counties would include all 236 identified as having at least some problem.

There are indications that the acreage targeted under a ground water quality program do not overlap with that targeted for a surface water program. Almost half (26) counties targeted in the ground water program did not contain any acreage in the surface water program. The remaining 32 counties contained only 744 thousand acres identified in the surface water scenario. This is partly due to the different geographic units used; NRI points for surface water versus counties for ground water. However, the 236 counties identified as having some level of ground water quality problem contain only 1.1 million acres of the cropland targeted for surface water quality. This is fairly strong evidence that surface water and ground water quality problems do not overlap as far as agriculture is concerned.

The price effects of the ground water program are similar to those of the surface water program, except for a greater increase for rice and less of an increase for wheat. The acreage of corn and soybeans retired are very similar, while wheat acreage was somewhat less for the ground water program. CCC payment savings would also be similar, being dominated by corn price movements. The estimated government costs for the ground water program are about $12 billion.

Combined Program

Based on the evidence presented above, a combined ground water-surface water program would not find much common acreage to target. Instead, acreage for surface water quality and acreage for ground water quality would have to be selected separately. Ideally, the choice between surface water protection and ground water protection would be based on potential economic benefits, including benefits from reduced health risk. Without potential economic benefits from ground water quality protection, a ranking system for choosing between the two problems would have to be devised.

Conclusions

An expansion of the CRP to address surface water and ground water quality issues is possible and would generate economic benefits for water users. Whether such a program is actually implemented will probably not depend on a social accounting of benefits and costs, but on federal budgetary concerns. If government program costs are sufficiently reduced, or not significantly increased, then the program has a chance.

Since the opportunities for addressing both surface and ground water problems by retiring the same fields appear to be limited, a decision must be made of how many acres to devote to each problem. Since the monetary benefits from ground water protection are exceedingly difficult to estimate, and the benefits from surface water quality protection slightly less so, other factors must be used in reaching a consensus. One source of information could the Water Quality Assessments prepared by the states to meet the requirements of Section 319 of the 1987 Water Quality Act. Another could be state information on well recharge areas.

Based on the results, cropland eligible for the program should not be restricted to "highly-erodible". This is especially true for ground water protection and for surface water protection in regions where water is highly valued. If crop yields are inversely correlated with erosion rate, then higher rental rates will be required to attract less-erodible land into the program. Eligibility would also be contingent on contributing to a water quality problem. The information necessary to make that assessment is, of course, much harder to come by than simply the erosion rate.

An issue that should be addressed is whether whole-field retirement is the best approach for protecting surface water quality. Buffer strips and sediment basins may be the most cost effective approach for protecting specific stream reaches. However, more study if needed on the question of buffer effectiveness, longevity, and management needs.

Table 1 - Benefits of 10 Million Acre Surface Water Quality Option.

Region	Acres	Annual Water quality benefits	Per-acre erosion reduction
	million acres	million dollars	tons
Appalachian	1.13	30 - 87	53.8
Corn Belt	2.83	41 - 147	52.3
Delta	0.52	18 - 102	31.6
Lake States	1.56	31 - 93	18.7
Mountain	0.02	1 - 2	38.7
Northeast	2.69	57 - 191	14.6
Northern Plains	0.09	3 - 22	83.5
Pacific	0.67	69 - 215	26.5
Southeast	0.34	10 - 22	31.2
Southern Plains	0.15	3 - 10	23.9
Total	10.00	236 - 891	33.4

Table 2 - Comparison of Acreage Identified for Surface and Ground Water Quality Options by Region.

Region	Surface Water	Ground Water
	million acres	
Appalachian	1.13	1.37
Corn Belt	2.83	2.69
Delta	0.52	0.27
Lake States	1.56	2.59
Mountain	0.02	0
Northeast	2.69	1.32
Northern Plains	0.09	0
Pacific	0.67	0.35
Southeast	0.34	1.12
Southern Plains	0.15	0
Total	10.00	10.00

Table 3 - Comparison of Acreage Identified for Surface and Ground Water Quality Options by Commodity.

Region	Surface Water	Ground Water
	million acres	
Corn	4.50	4.27
Sorghum	0.12	0.02
Soybeans	2.19	2.35
Cotton	0.13	0.10
Wheat	0.90	0.64
Oats	0.27	0.26
Barley	0.11	0.03
Fallow and hay	0.58	1.34
Total	10.00	10.00

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Figure 1.

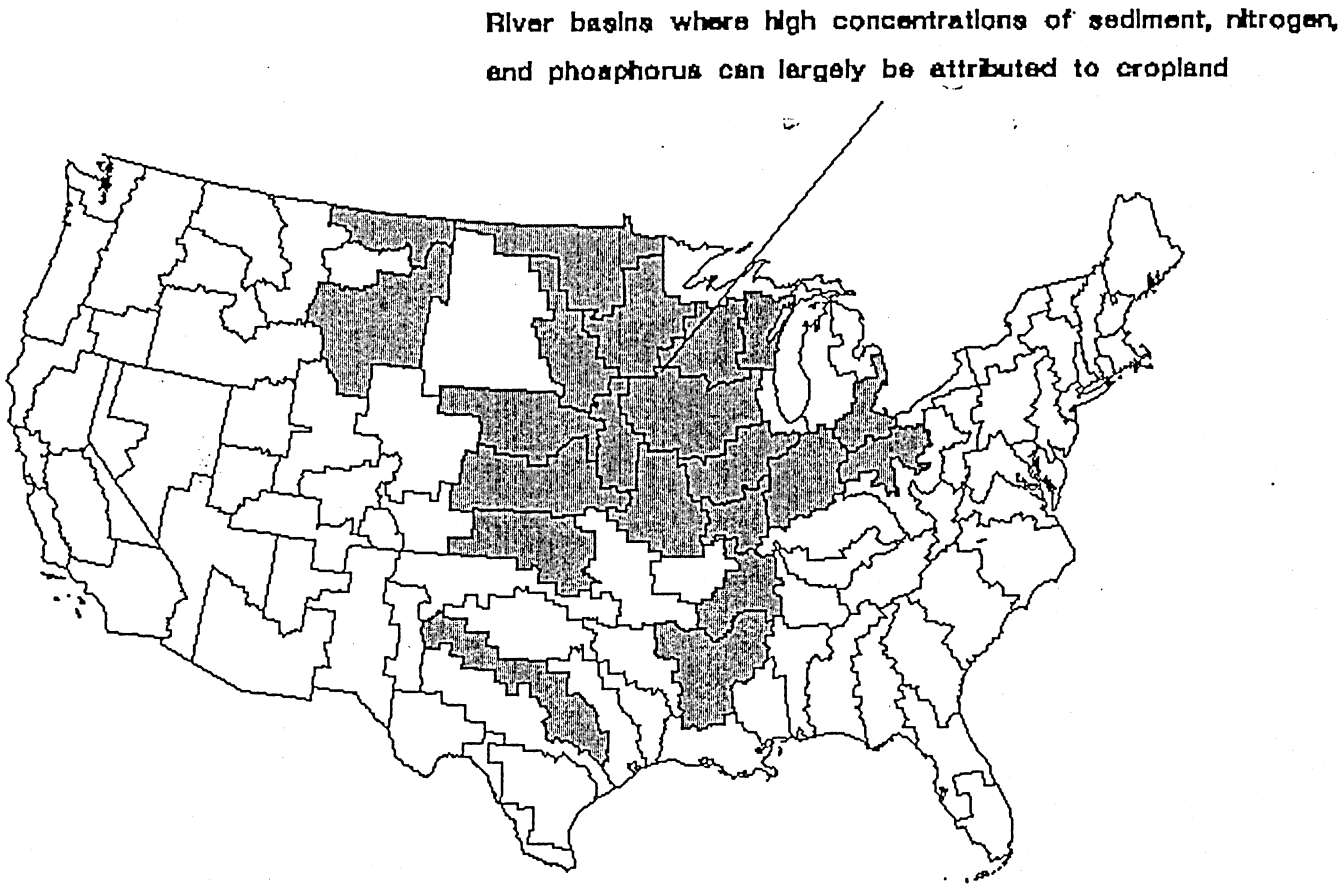
River basins where high concentrations of sediment, nitrogen, and phosphorus can largely be attributed to cropland

Figure 2.

Counties Vulnerable to Ground Water Contamination

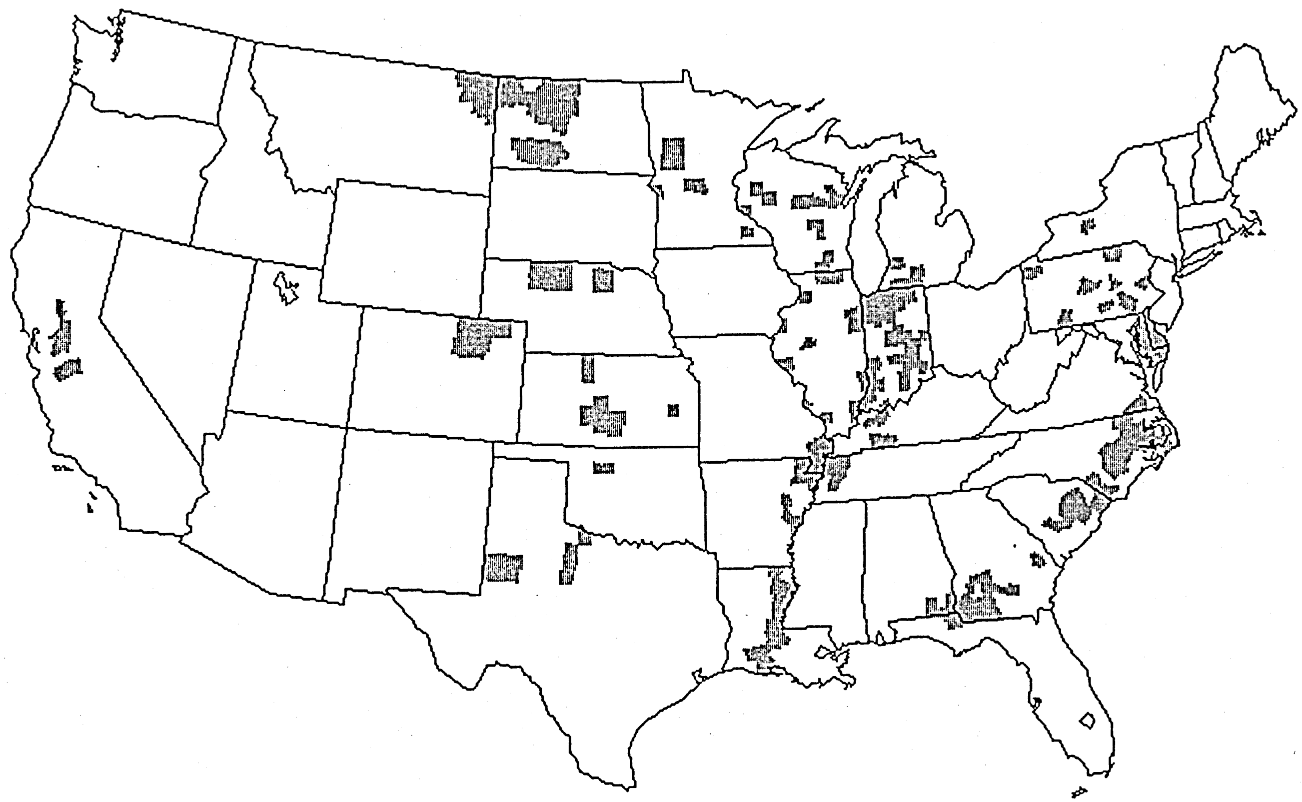

Figure 3.

LOCATION OF CROPLAND TO BE RETIRED ON BASIS OF POTENTIAL WATER QUALITY BENEFITS