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Designing Green Support Programs

Sarah Lynch
Editor

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Preface

"Designing Green Support Programs" is the second in a series of reports on Green Support Programs from the Henry A. Wallace Institute for Alternative Agriculture. The first report in this series, "Lean, Mean and Green...Designing Farm Support Programs in a New Era," by Sarah Lynch and Katherine R. Smith, provides a broad overview of the concept of Green Support Programs (GSP). A GSP would combine in one program the dual objectives of supporting farmers income and providing environmental protection from agricultural pollution. "Lean, Mean and Green..." identifies critical decisions that must be made in designing a GSP and explores the implications and trade-offs of alternative program designs.

"Designing Green Support Programs" provides an in-depth analysis of several of the critical decisions that must be made in designing a GSP. In the first paper of this volume, Sarah Lynch provides a brief overview of agriculture's environmental problems and highlights some of the strengths and weaknesses of alternative approaches to addressing these problems. Ralph E. Heimlich explores the geographic distribution of potential agroenvironmental problems and discusses the implications of this distribution on program targeting to enhance cost-effectiveness. The issue of incentive compatibility between existing farm programs and a GSP is examined by C. Ford Runge. Sandra Batie discusses the availability of sustainable, environmentally friendly alternative technologies and production practices, and barriers to their adoption. Finally, Jerry Skees explores program administration issues that must be confronted when designing and implementing a GSP.

Collectively, these papers add considerable depth to our understanding of the important issues and trade-offs that must be considered in designing a GSP. In so doing they inform the on-going debate over the strengths and limitations of GSPs and the potential role they might play in the next generation of farm programs.

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Designing Green Farm Programs: A Range of Options

by Sarah Lynch

INTRODUCTION

Debate over the 1995 Farm Bill is already under way and with it has come the renewed call for substantial reform of existing farm programs. Many of these programs were designed and put in place in response to the problems and prospects of farmers during the Great Depression in the 1930's. The world has changed substantially during the last six decades and many of the Depression-era policies and programs no longer efficiently address the critical contemporary problems that farmers face. A growing consensus has emerged among scholars, agri-business, politicians and farmers on the need for major reform of farm legislation. Common criticisms of existing farm programs include that they are not cost-effective, place an unwarranted drain on the Federal treasury, reduce international competitiveness, weaken farmers' responsiveness to market signals, and encourage practices harmful to the environment (Tweeten, 1994).

While many of these calls for reform have been heard in previous Farm Bill debates, most changes in farm policy have been incremental. However, several factors increase the possibility of achieving major reform of farm programs during the 1995 legislative process. Republican control of Congress and the party's stated commitment to balancing the budget heightens the vulnerability of farm programs to ever more drastic budget cuts. The recent signing into law of the GATT (Generalized Agreement on Tariffs and Trade) and NAFTA (North American Free Trade Agreement) creates additional pressure to eliminate the price and commodity supply distortions that existing farm programs engender. Public support for continued taxpayer transfers to farmers has continued to weaken due to the growing public perception that society reaps low returns on taxpayers investment in agriculture, that the lion's share of farm program benefits goes to well-off farmers, and that farmers are not being "good stewards" of the land.

An alternative farm program option currently under consideration is a "green" or "stewardship" support program. Such a program would be a voluntary program providing direct monetary payments to farmers and/or farm landowners for the provision of environmental benefit(s). Given the general dissatisfaction with existing farm programs, a green support program (GSP) potentially offers great appeal as an alternative approach. The essence of this appeal is that a GSP would be acceptable under the GATT and NAFTA, provide farm income support without introducing the distortions in price and commodity supplies that current farm programs promote, and address the public's growing concern about environmental quality and food safety.

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Sarah Lynch is a Senior Policy Analyst at the Henry A. Wallace Institute for Alternative Agriculture in Greenbelt, Maryland.

Clearly, depending on objectives, there are a variety of ways a GSP could be designed. Each potential design has important implications regarding which individuals, regions, population sub-groups, and farm types gain or lose; the types of environmental problems addressed and the degree to which they can be resolved; and the program's total cost and impact on the federal budget (Lynch and Smith, 1994).

The four papers that follow by Ralph Heimlich, C. Ford Runge, Sandra Batie and Jerry Skees, discuss implications of alternative GSP designs in detail. This introductory paper sets the stage for the more detailed discussion of design options, by first providing a brief overview of agroenvironmental problems and then discussing the range of potential policy options available. Understanding some of the trade-offs between alternative policy instruments available to address agriculture's environmental impacts will help to clarify the strengths and weaknesses inherent in the choice of a green support program.

The Nature of the Problem: Special Issues in Agroenvironmental Pollution

A host of environmental problems are associated with agricultural production. Crop production may release sediments that result in siltation of navigable waterways, drainage ditches, irrigation canals, water storage areas, and streams. Such sedimentation in surface waters can impair vegetative and fish growth which in turn can lead to negative impacts on recreational uses. Soil erosion also can contribute to decreased soil productivity and, if wind borne, to air pollution. The presence, in both surface and groundwater sources of drinking water, of nutrients (mainly from animal waste and fertilizer residuals) and pesticides poses potential human health risks. The detection of residues of a range of pre- and post-harvest synthetic chemicals on agricultural products has generated concerns about food safety. The conversion and intensive use of agricultural land also has decreased the availability and/or quality of wildlife habitat (Crutchfield, et al., 1993; Libby and Boggess, 1990; Reichelderfer, 1990).

While different groups may debate the degree of risk generated by some of these environmental problems, no one questions that the off-farm effects of agricultural pollution impose a cost on society (e.g., the costs of monitoring and treating contaminated water, restoring or mitigating degraded natural environments, lost recreational opportunities, dredging clogged waterways, etc.). Although difficult to quantify, some estimates have put the actual monetary costs to society resulting from agricultural production in the billions of dollars (Crutchfield, 1993; Reichelderfer, 1990). The difficulty in addressing these costs directly is that the public cost of the pollution generated by agriculture is not accounted for in the private decisions of producers. Individual farmer's cost benefit calculations typically do not account for the unintended, usually offsite, consequences to the environment of production decisions, because the market generally fails to differentiate between the products of agricultural production systems that do not pollute and those that do. This "market failure" suggests the need for some kind of policy intervention (Crutchfield et al., 1993; Libby and Boggess, 1990).

Clearly, market failure is a problem not only for agricultural pollution, but also for urban and industrial pollution as well. However, agricultural pollution has several other characteristics that warrant special attention when designing abatement or mitigation policies. These special characteristics of agricultural pollution — its non-point nature, the uneven distribution of environmental problems, the collective nature of environmental problems, timelags, the evolving scientific understanding, and overlap between environmental problems — while not unique to agriculture, have implications for the feasibility and efficiency of the different policy instruments available for addressing agriculture's impact on the environment.

Non-Point Source Pollution

One of the major considerations in addressing agricultural pollution is the fact that, in general, it is non-point pollution. This means that unlike many kinds of urban and industrial point-source pollution, where emissions often can be directly traced to a precise source such as a pipe or chimney, agricultural non-point source pollution is diffuse, originating on fields scattered throughout the countryside. Because non-point pollution originates over a wide area and multiple enterprises, it is difficult to attribute the discharge of pollutants to a specific farm.

The non-point nature of many forms of agricultural pollution has broad implications for the cost and effectiveness of different policy options. For example, given the current state of technology, it is difficult and costly to measure the pollution discharged from an individual field or farm. Compared to point sources of pollution, there are few opportunities for treating non-point agricultural pollution after it is generated. With limited possibilities for abatement, efforts to control agricultural pollution must focus on altering farmers' production decisions. Furthermore, the difficulty in monitoring discharges limits the possibility of establishing and enforcing a clear performance standard to ensure that farmers are complying with program objectives. The inability to enforce a performance standard leads to the use of proxy measures to gauge program effectiveness (e.g. reduced soil erosion), which only approximate the desired environmental objective.

Uneven Distribution of Environmental Problems

Agricultural production related environmental problems vary considerably in terms of type(s) and magnitude from one location to another (Heimlich, 1994b). The variation in type, combination and intensity of environmental impacts reflects the combined influence of three critical factors: the geophysical base, site specific agricultural production possibilities, and human and institutional factors. The geophysical base consists of the specific characteristics of the land being farmed such as soil type and depth, slope, proximity to water bodies, amount of rainfall, etc. The production possibilities encompass the types of crops grown, enterprise mixes, and production systems used. Finally, the human element — the social and economic objectives and managerial abilities of individual farmers — is reflected in the myriad production decisions that farm owners and operators make daily.

These factors combine in often unpredictable ways to influence the potential for a particular kind or combination of environmental problems. For example, the transport of a particular pesticide or fertilizer product through the soil into a groundwater source depends not only on site-specific geophysical variables, but also on weather conditions, and on the frequency, timing and application method of the products themselves. For example, the same crop production in two different regions can generate vastly different environmental impacts because of differences in the underlying geophysical conditions.

This has two important impacts for designing policy. First, because the type, combination and intensity of environmental problems caused by agriculture vary from region to region and farm to farm, some farms contribute little to environmental pollution, while others contribute a lot. The most cost-effective policy should target attention to problem farms in priority areas (Batie, 1994; Heimlich, 1994). Second, solutions to the different types of problems caused in agriculture must be tailored to site-specific conditions. Since the causes of agricultural pollution can vary significantly depending on site-specific conditions, it stands to reason that the solutions also must be individually tailored to those same conditions.

Collective Nature of Environmental Problems

The pollution generated by agricultural production is largely a collective problem. The myriad production decisions made by numerous producers over a wide region all contribute to the creation and severity of a particular agricultural problem or set of problems. However, some producers contribute more and others less. Because of the diffuse sources of agricultural pollution in any given watershed or region, mitigation will require a critical mass of participants in order to see a significant gain in environmental quality. The success of any particular policy option in achieving a measurable improvement in environmental quality will depend, in part, on achieving this critical mass.

Time Lags

For some types of agroenvironmental problems significant time lags exist between a change in behavior or production practices to redress a particular problem and observation of measurable improvement in the environment. For example, some synthetic chemicals used in agriculture can persist in the environment for a decade after use has been eliminated. Thus, the presence of time lags can complicate establishing performance standards because of the delays in observing measurable change in the environment. The presence of lags also underscores the need for a long-term commitment to alternative production practices and behavior, in priority areas and on problem farms, if measurable and sustained environmental improvement is to be achieved.

Evolving Scientific Understanding

An additional problem of addressing agricultural pollution results from the fact that we know only a limited amount about the complex interactions between agriculture and the environment. We have an incomplete base of knowledge to make fully-informed choices of production technologies, practices, and inputs that affect environmental concerns such as water quality, human health, global warming, bio-diversity, and food safety. This knowledge gap is not unique to agriculture. However, regardless of the gaps in knowledge, policy makers must make choices using the best information available at the time. This information unfortunately will be incomplete and/or contradictory in some cases. Thus, it is imperative that agricultural pollution solutions be dynamic, adaptive, and flexible.

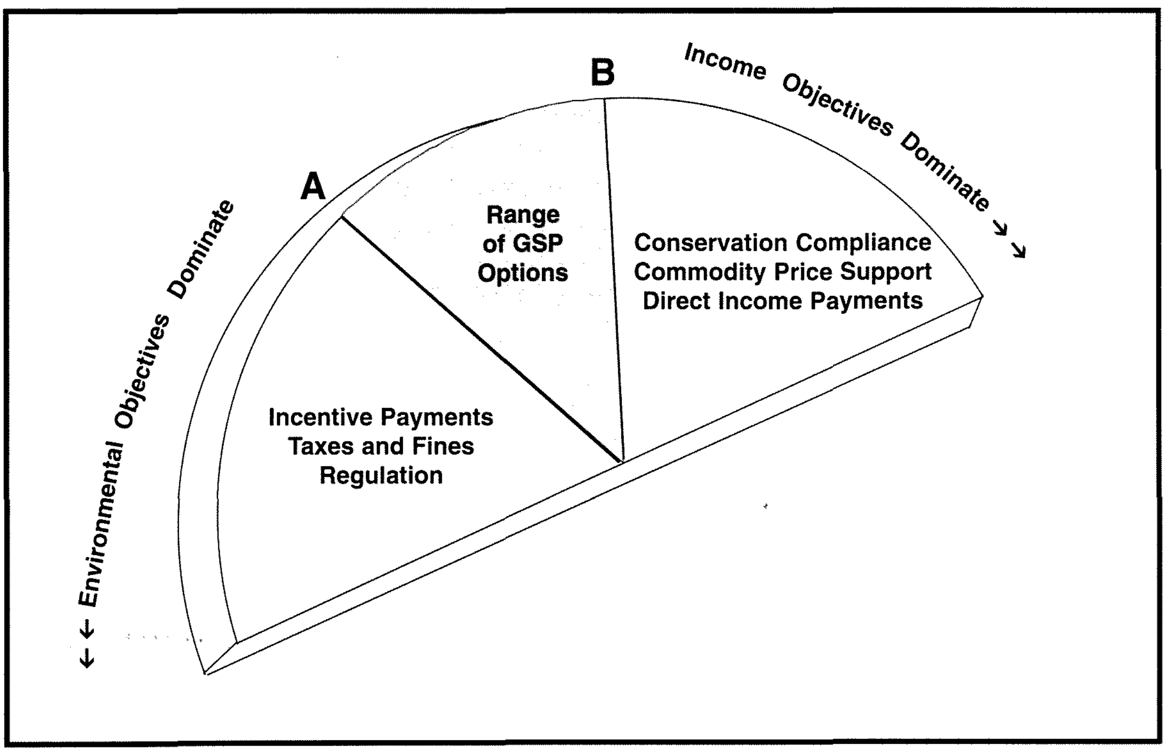
Overlap Between Environmental Problems

Because the relationship between agriculture and the environment is complex, production practices can contribute to more than one type of environmental problem. Thus, measures taken to mitigate one type of pollution may exacerbate another. For example, the increased use of reduced tillage has lessened surface water contamination by minimizing runoff from fertilizers and pesticide applications. In some cases, however, it also has increased the potential for groundwater contamination. The fact that different types of pollution problems are sometimes linked together suggests the need to develop farm level solutions, using a comprehensive farm planning process rather than a problem-by-problem approach. Such a process would take into consideration the myriad ways different farm enterprises, physical characteristics, and management decisions interact to create one or more environmental consequences.

The Range of Green Policy Options

Under consideration during the 1995 Farm Bill debate will be a number of different policy approaches to addressing agriculture's impact on the environment. These options range from modest changes in existing conservation and farm support programs to the radical transformation of these programs. The options reflect different orientations in how to approach the task of improving agriculture's environmental impact, and encompass choices as to the dominance of income support or environmental objectives, whether programs should be voluntary or non-voluntary, and the use of a carrot or a stick approach (Figure 1).

Figure 1. A wide range of policy options are available for addressing agriculture's impact on the environment.



Historically, Federal agricultural policy has addressed environmental impacts by encouraging voluntary participation of farmers in conservation programs. Federal programs share the cost of implementing certain conservation practices on farmers' land, provide monetary incentives to keep land out of production and under protective cover, and provide technical assistance. Publicly funded research and development contribute to the development of more "environmentally friendly" technologies, inputs, and production practices. More recently, through Conservation Compliance, Swampbuster and Sodbuster measures initiated in the 1985 Farm Bill, some farmers have had to conform to environmental restrictions in order to receive farm program payments. In addition to Federal programs, however, farmers are also influenced by state policies. Individual state governments, in their efforts to address environmental problems created by agriculture, have employed a wider range of policy options including regulation, taxes, and fees, as well as the more traditional voluntary approaches favored by the Federal government.

Evaluation Criteria

Evaluating the strengths and limitations of different policy approaches requires assessing economic efficiency, budgetary impacts (including administrative costs), and distributional implications of different options. In addition, however, an important philosophical or ethical question arises: Who should bear the costs, often offsite, resulting from agricultural pollution? The "polluter pays" principle that has guided many non-agricultural pollution control strategies implies that society at large has the right to a clean environment, and that polluters must pay for the damage they do to the environment. They can "pay" through their expenditures on abatement measures adopted, taxes, fees, and/or lost income because of foregone economic opportunities. The opposite view is that any infringement of economic opportunities imposes an unconstitutional "taking," and thus requires compensation by society for that loss. In the former view, society's right to a clean environment would dominate an individual landowner's right to farm as he or she wished. In the latter view, the landowner's rights would dominate society's right to a clean environment.

Public policy usually lies somewhere between these two extreme positions. Court opinion is in flux, but recent decisions would seem to suggest that society has a right to expect landowners to bear some of the costs of addressing their off-site environmental impacts. However, two conditions need to be met. First, the regulator must establish a clear link between the regulated activity an public benefits, and second, the exercise of public rights should not remove all economic value from the landowner's property.

Some of the major points to consider in evaluating the strengths and weaknesses of alternative options are summarized below. Segerson (1990), Anderson et al. (1990) and Libby and Boggess (1990) provide a more detailed evaluation of alternative pollution control options.

Regulatory Approach

Adopting a regulatory approach imposes the "polluter pays" principle and in so doing establishes the dominance of the public's right to a non-degraded environment over the rights of individual producers. Regulations rely on the enforcement of performance standards or direct controls on the outputs produced or on the use of inputs and production practices. Depending on design, these controls can be targeted to specific regions or farms using certain production practices, or more uniformly applied across all farm types and regions.

Regulation has been a cost-effective method of achieving pollution reduction in other situations. However, non-point pollution generated by agricultural production may be less amenable to regulation for several reasons. First, as noted earlier, the diverse and dispersed contributors to a specific pollution problem limit, in general, the opportunities for ex-post treatment of agricultural emissions (Anderson, et al., 1990). Because of the difficulties in establishing performance standards, regulatory approaches would have to concentrate on modifying farmers' production decisions, either by restricting the use of certain practices and types of inputs or by requiring the adoption of certain "best management practices." Monitoring and enforcing regulations on individual farms would be difficult and impose high administrative costs. In addition, technological innovation in pollution control can be stymied with regulations that stipulate the use of specific technologies or practices (Segerson, 1990).

Second, cultural, political and historical characteristics of the farm sector have shielded farmers from regulatory approaches in the past. Society's reverence of the agrarian heritage, the perception of farmers as good stewards, and the disproportionate strength of farm interests in the U.S. Congress all have contributed, in the past, to a resistance to relying on a regulatory approach in agriculture. Furthermore, the institutional culture of the U.S. Department of Agriculture has traditionally not been oriented toward the regulation of farmers, although the Soil Conservation Service has begun to play a somewhat more regulatory role in recent years.

Third, regulations change the distribution of income within the farm sector — some farmers benefit while others lose. The most adversely affected are those producers who have fewer substitution possibilities for the restricted outputs or inputs. The resulting change in income distribution may not conform with other stated societal objectives. For example, "small family farms" may be among those disproportionately affected by regulations, thereby creating a trade-off between two important societal objectives of protecting the environment and preserving the family farm.

Regulations can have other adverse impacts. Inefficiencies in production and consumption can result if the regulations distort factor markets. Consumers could see an increase in product prices if regulations increase the average cost of production, which may be politically unpalatable. This could have an adverse impact on international competitiveness. Regulations, especially those that restrict use of certain inputs, also can have an adverse impact on agribusiness (Reichelderfer, 1990).

Incentive Programs

Unlike the regulatory approach, which controls pollution directly by restricting or prohibiting specific activities, the incentive approach controls pollution generation indirectly. An incentive aims to modify farmers' behavior by changing the prices they face. In response to these price changes, farmers should voluntarily change their behavior, with the expected result being a reduction in pollution generation. The incentive can come either in the form of a subsidy (a "carrot") or taxes and fees (a "stick") on output, inputs, and/or pollution levels. (Segerson, 1990; Anderson, et al., 1990).

Taxes and Fees

Taxes and fees can be imposed on outputs, emissions (or a proxy), or inputs. For example, a tax could be placed on a particular fertilizer or pesticide in an effort to reduce its use. One of the main problems encountered with this approach is the difficulty in establishing the optimal fee structure that results in the desired changes in polluting activities. Several factors contribute to this difficulty. First, it is hard to establish standards because emission taxes are not feasible given the non-point nature of agricultural pollution. Second, the transport and fate of agricultural chemicals as they pass through the environment are variable and poorly understood (Reichelderfer, 1990). Third, the tax imposed would have to be quite high in order to achieve a "measurable" impact, because empirical evidence suggests that the demand for some agricultural chemicals is relatively unresponsive to changes in price (Segerson, 1990).

Taxes and fees are, however, generally preferred for efficiency reasons over regulation. This preference stems from the belief that an appropriately designed tax or fee allows farmers to adjust their production practices in the least-cost manner. In theory, this would result in a more efficient allocation of resources all other things being equal (Segerson, 1990; Reichelderfer, 1990).

Subsidies

Subsidies, like taxes and fees, can be designed to affect output levels, input use, or levels of pollution generated. For example, subsidies can be provided to reduce the use of certain agricultural chemicals or for the adoption of specific practices. However, the establishment of payment schedules for subsidies encounter many of the same problems as taxes and fees.

Taxes or subsidies can generate the same incentive for individual modification of behavior, although it may be easier to administer the former (Segerson, 1990). However, a critical difference between the two approaches is that imposing a tax or fee is an extension of the polluter pays principle while the use of a subsidy establishes a means for society to compensate or bribe farmers in order to acquire environmental benefits. Because of historical precedence, subsidies likely will be more politically palatable than taxes and fees.

Green Support Programs

A GSP is a hybrid program consisting of elements of a subsidy approach to achieve environmental objectives, coupled with the more traditional farm program objective of income support. Thus, a GSP has the dual objectives of providing income support to farmers in return for the provision of environmental benefits.

A GSP would change the basis upon which farm income support would be provided. As mentioned in the introduction, this potentially could have numerous benefits in terms of providing farmers greater production flexibility, and allowing them to be more responsive to market conditions and more competitive internationally. It also would generate environmental benefits. Because it continues in the traditional vein of previous conservation efforts, and provides "carrots" rather than "sticks," it may be a politically more attractive approach. By relying on a subsidy approach, it also avoids the contentious issue of "takings" discussed earlier.

Similar to other incentive based approaches, and for the same reasons, monitoring and enforcing a GSP and establishing the appropriate payment schedule structure would be difficult. The process of establishing a payment schedule is further complicated by the fact that the incentive structure also would have to serve an income support objective. Thus, the payment levels would need to vary in response to changes in agricultural prices (Lynch and Smith, 1994).

The fact that a GSP would be a voluntary program creates additional concerns about both who is eligible and who will want to participate. In terms of the former, eligibility can be based on income or environmental criteria, or on some combination of the two. The degree of compatibility between the two objectives depends on the extent to which the population of farmers generating priority environmental problems overlaps with the population of farmers qualifying for income support. As Heimlich (1994) points out in his analysis, the overlap between the current participants in farm income support programs and environmental priority areas, as he defines them, is limited. This underscores the important distributional implications of determining eligibility criteria for a GSP.

Unlike many regulatory and incentive approaches, which are non-voluntary, a GSP would be based on voluntary participation. Careful attention needs to be paid to the critical factors that will influence both the number and type of farmers who will want to participate. Obviously, the attractiveness of the incentives offered and the alternatives available at the time will be major influences. However, additional factors warrant consideration, some of which are summarized by Batie (1994):

> ... successful voluntary programs tend to occur where producers are aware of their contribution to an environmental problem they believe is important, where the benefits of participation are not swamped by the costs, where the producers have assisted in program design, implementation and enforcement, where education programs are tailored to producer needs, and where an implicit or explicit threat of future regulatory programs exist.

Continuation of existing programs

Continuation or marginal changes in the existing set of farm programs are also possible options. However, as noted previously, the pressure for reform continues to threaten the status quo. While changes can make current farm support programs more flexible or expand conservation compliance measures to more acres, the impact of incremental changes on agricultural pollution likely will be limited.

Conclusions

Agriculture interacts with the environment in complex ways. The tremendous diversity found in agro-climatic conditions and agricultural and livestock systems, coupled with differences in the abilities and objectives of the roughly 2 million U.S. farmers, contribute to this complexity. These same factors complicate the design of policies to address the environmental problems created by agriculture. As a result, no one policy option is optimal with respect to all evaluation criteria. Each option has strengths and weaknesses. As Segerson (1990, p 56) concluded in her review of policy issues relating to water pollution:

> Choices of the specific instruments to be used will require a balancing of multiple objectives, relating to efficiency, distributional implications,

> budgetary effects, and administrative ease (low transactions costs). A policy package that attempts to balance these concerns will be imperfect in terms of any single criterion, and it should not be judged in that way. Instead, it must be evaluated as a compromise solution to an environmental problem that defies easy solution.

Understanding the strengths and limitations inherent in the choice of a voluntary, subsidy-based program such as a GSP will enhance our ability to design a more cost-effective program. Furthermore, it will make more realistic the expectations about what such a program can and cannot achieve.

The four papers that follow explore in depth important issues relating to the design and implementation of a GSP. Ralph E. Heimlich assesses the geographic distribution of potential agroenvironmental problems, and discusses the implications that this distribution has on program targeting for cost-effectiveness. The issue of incentive compatibility between existing farm programs and a GSP is studied by C. Ford Runge. Sandra Batie discusses the availability of sustainable, environmentally-friendly alternative technologies and production practices, and barriers to their adoption. Finally, Jerry Skees examines program administration and implementation issues that must be confronted when designing and implementing a GSP. Collectively, these papers add considerable depth to our understanding of the important issues and trade-offs that must be considered in designing a GSP.

Targeting Green Support Payments: The Geographic Interface between Agriculture and the Environment

by Ralph E. Heimlich

INTRODUCTION

Quadrennial omnibus farm legislation has for the last fifteen years presented an opportunity to propose and debate new programs to conserve and protect natural resources affected by agricultural production. The 1981 Farm Act included the Farmland Protection Policy Act, directing USDA to identify and track Federal actions with adverse effects on farmland and was the first farm act to contain an explicit title for conservation programs. In the 1985 Food Security Act, the Conservation Reserve Program (CRP) recast familiar long-term land retirement programs in a new light targeted more directly at reducing soil erosion and attendant water quality problems from highly erodible cropland. Other innovative programs addressed adverse environmental impacts caused, in part, by farm commodity program payments. The so-called conservation compliance, sodbuster, and swampbuster provisions mitigated impacts on soil and wetlands by requiring implementation of conservation plans on highly erodible cropland and denying payments for new cropland developed on highly erodible soils or from wetlands.

The 1990 Food, Agriculture, Conservation, and Trade Act (FACTA) refined these earlier programs and proposed three innovations. The Wetland Reserve Program (WRP) compensated landowners for restoring their cropland to wetland and permanently foregoing crop production. The Water Quality Incentives Program (WQIP) provided a voluntary incentive program through agreements to assist farm owners and operators in developing and implementing a water quality improvement plan. The Integrated Farm Management Program (IFM) established a voluntary program designed to assist producers in adopting integrated, multiyear, site-specific farm management plans and reducing farm program barriers to resource stewardship practices and systems.

The 1995 Farm Bill debate offers new opportunities to further refine existing conservation programs and develop new ones. Increased and broadened awareness of agricultural's environmental role, declining farm program payments, and the prospect of a changing basis for farm support payments are all cited as arguments in favor of

Ralph E. Heimlich is the Geographic Information Systems Teamleader in the Natural Resources and Environment Division, Economic Research Service, USDA. The opinions presented in this paper are the author's and do not necessarily represent official USDA policy or positions.

paying farmers to change land use or farming systems in order to provide environmental services (Ervin, 1993; Osborn, et al., 1993; Runge, 1994). This concept, variously labeled green recoupling, stewardship payments, or green support payments, could take several forms: a renewed and targeted CRP, extended conservation compliance, or incentive and cost-sharing programs such as ACP, WQIP, and IFM (Ribaudo et al., 1990; Heimlich and Osborn, 1993; Allen, 1993, 1994; Reynolds, et al., 1994; NRC, 1993).

Regardless of the exact mechanisms on which a green support program is based, knowledge of the geographic association between agriculture and environmental problems is critical. The objective of this paper is to show how environmental indicators, developed using readily available data, can provide information on the geographic distribution of potential environmental damages from agricultural production. Such targeting indicates potential benefits for green support programs aimed at improving environmental conditions. The ability to identify, prioritize, and target environmental problems is important for designing cost-effective programs, assessing which producers gain or lose from changes in support mechanisms, and assessing the types and magnitudes of environmental benefits achieved.

This analysis advances the development of environmental indicators by explicitly recognizing that the environment is fundamentally a spatial phenomenon requiring spatial indicators, and by actually constructing quantitative indicators of the potential for specific types of environmental damages. This effort builds on an environmental benefits index developed to assess CRP bids after the 1990 FACTA. The indicators described here are better indicators of the benefits they are designed to represent than those used in earlier efforts, most of which were based primarily on cropland soil erosion. Nonetheless, this set of indicators should not be construed as complete or final. Both new environmental problems and new sources of data are arising or being developed that should be incorporated. Despite their limitations, these environmental indicators do demonstrate the feasibility of targeting programs to environmental improvement objectives in order to achieve greater cost-effectiveness.

Environmental indicators presented here represent a significant improvement on previous efforts to geographically locate environmental problems associated with U.S. agriculture at the national scale. They demonstrate the feasibility of using readily available sources of data to characterize the relative environmental performance of cropland in different parts of the country. These indicators are thus illustrative of a method that can be used and further refined, rather than a definitive or final answer.

The measures developed here are indicators of potential environmental problems (type 1 in Nelson, 1994), and for the most part do not reflect any direct measurement of environmental harm created by agricultural production. This potential for environmental harm may, or may not, be realized depending on whether mitigating conditions not captured in the indicator are present. For example, potential pesticide leaching may be diverted as pesticide loads to surface water if artificial drainage diverts water percolating below the root zone away from groundwater.

The costs of potential environmental damages, or benefits of remediation are proxied by population weights attached to each observation. The relative value of soil productivity lost to erosion is proxied by cash rent. These weights are a first, crude approach to measuring, or at least proxying for the cost of environmental externalities.

While tentative, these weights provide valuable information to target programs directed at preventing or improving environmental problems associated with agricultural production.

Targeting for Cost-Effectiveness

The cost-effectiveness of environmental programs dealing with problems related to agricultural production can be improved by targeting land with the greatest environmental benefits and recognizing the opportunity cost of foregoing all or part of agricultural production. An issue for green support programs is the degree of correspondence between current constituents now receiving farm program payments and cropland with potential environmental problems. A GIS analysis at the national level can indicate areas of overlap between where high and low farm program payments are received and where potential environmental problem indices are high and low.

Why is targeting needed for conservation and environmental programs? Just as with any program that has limited resources, conservation programs cannot be expected to achieve optimal results unless the funds are directed where they can generate the greatest improvement for the funds available. Targeting can be done in different ways and at more than one level within a particular program. For example, focusing the Conservation Reserve and Conservation Compliance Programs on highly erodible cropland in the 1985 Food Security Act "targeted" the programs to a subcategory of U.S. cropland that was responsible for a large portion of total cropland soil erosion. Criteria for other environmentally sensitive lands (wetlands, scour erosion areas, water quality areas) were added to the CRP later.

After the 1990 Farm Act, changes in CRP bid assessment procedures resulted in further targeting to enroll only the most cost-effective land submitted. Proxies for environmental benefits were developed based on readily available data reflecting onsite soil productivity, surface and groundwater quality, and assistance to farmers most affected by conservation compliance. Where appropriate, these indicators were weighted by the population affected. Bid assessment was centralized in Washington, using data on bids provided by local ASCS and SCS offices.

As an alternative to centralized targeting, program funding could be allocated to each state or region based on the kind of environmental indicators developed here and expected program costs. This kind of targeting would leave the choice of specific participants to local decision makers, perhaps based on uniform guidelines from Washington.

Questions about how green support programs could be targeted include:

- Should programs be targeted to areas of intensive agricultural production, or areas where many people are affected by environmental problems associated with agricultural production?

- What criteria beyond highly erodible land should be considered? What are agriculture's most pressing potential environmental problems?

- Can better measures of potential offsite environmental effects be developed?

To facilitate discussion of green support programs, I developed potential indices based on a variety of offsite impacts beyond soil erosion (see table 1 and Appendix). Other indicators were considered for inclusion, but rejected because data were lacking or relatively simple computational methods were not available. Among these were a water quantity measure (excess or residual irrigation), phosphorus runoff (no data on current soil concentrations), and animal manure loadings (will be incorporated into nitrogen runoff calculations).

Most of the indicators are mapped in two ways: their pure physical form and with a socio-economic weighting. Weighting indices by population, value, or other variables assumed to be proportional to benefits from conservation programs changes the magnitude of potential environmental effects compared with unweighted indices. This may be desirable if the objective is to target economic benefits from green support programs rather than the physical problem itself.

For example, weighting sediment production by the population of watersheds likely to be affected by the delivered sediment reduces the importance of sediment produced in sparsely populated southern Iowa and northern Missouri, and in the Palouse region of eastern Washington and Idaho (figures 1 and 2). Population weighting emphasizes sediment delivered in the densely populated Northeast, around the Chicago lakeshore, and in the St. Louis area. Examining current erosion rates versus topsoil depth as a measure of potential productivity loss highlights problems with high erosion rates on thin soils in eastern Montana and Colorado, the Texas panhandle, South Dakota, eastern Nebraska, and along the east bank of the Mississippi Delta (figures 13 and 14). However, weighting by the cash rent value deemphasizes areas with less valuable soils in favor of erosion on the highly productive soils in the Corn Belt.

Weighting to proxy for damages associated with the indicators introduces other problems. Is population an adequate proxy for these damages? If so, which population? Arguably, nutrients and pesticides from the Corn Belt can effect water quality far downstream in the Mississippi and even into the Gulf of Mexico, as they were monitored to do with the unusual Midwest flooding in 1993 (Taylor, et al., 1994; Goolsby, et al., 1993.). The wildlife structure and diversity indicator is not weighted using population, but it could be argued that increases in common game species habitat primarily benefit local populations within 100 miles or so. While these problems are left for later research, weighted versions of the indicators are presented to stimulate discussion.

Table 1—Indicators of potential environmental benefits

Indicator	Affected Resource	Externality	Description	Weight
Sediment production	Surface water quality	Siltation of reservoirs, ditches, etc. (Clark et al., 1985, Ribaudo, 1986)	Gross sheet and rill erosion times delivery ratio	Watershed population
Nitrogen runoff	Surface water quality	Eutrophication, algae growth, biological oxygen demand (NRC, 1993)	Residual nitrogen in soil surface and rainfall runoff	Watershed population
Filter strips	Surface water quality	Immobilization of sediment, pesticides and nutrients in runoff (Dillaha, et al., 1989; NRC, 1993)	Cropland within 100 feet of stream or lake	Watershed population
Pesticide leaching	Groundwater quality	Pesticide contamination of drinking water supplies (Kellogg et al., 1992)	Pesticide and soil leaching potential	Population using groundwater
Nitrate leaching	Groundwater quality	Nitrate contamination of drinking water supplies (Kellogg et al., 1992)	Nitrate and soil leaching potential	Population using groundwater
Habitat structure and diversity	Wildlife habitat	Loss of wildlife numbers (USDA, 1989)	Change in breeding and feeding habitat structure and diversity	None
Threatened and endangered species	Wildlife habitat	Loss of biodiversity (Brady and Flather)	Number of listed species with known and potential habitat	None
Soil productivity	Soil erosion	Loss of sustainable production (Batie, 1983)	Topsoil depth divided by loss of depth from erosion per year	Dryland cash rent per year
Windblown dust	Soil erosion	Health, cleanliness and maintenance costs of windblown dust (Huszar and Piper, 1986)	Wind erosion rate	County population
Pesticide exposure	Other	Human and environmental exposure to toxic materials (Kovach, et al., 1992)	Pounds of active ingredient times toxicity and persistence	None
Flood peak reduction	Other	Damages from increased flooding (NRC, 1992)	Cropland on former wetlands within the 100 year floodplain	Watershed population

Results of Mapping Agricultural Environmental Indicators

The maps presented here are based on data for the 323,000 cropland points in the 1982 National Resources Inventory, matched to their respective soil interpretations from the SOILS 5 database. They are mapped to 18,530 NRI polygons, a three-way layering of county, major land resource area (MLRA), and hydrologic unit (watershed) boundaries developed by Margaret Maizel in cooperative work with ERS (Kellogg, et al., 1992). All indices are developed at the sample point level, then aggregated to the NRI polygon for mapping by taking the acreage-weighted average of the index value. Indices are normalized to a 0-100 interval by dividing the average NRI polygon score by the maximum score for any NRI polygon and multiplying by 100. The composite index is summed across index components at the NRI polygon level, then renormalized to the 0-100 interval based on the maximum polygon sum. The composite thus implies equal weighting of the index components included.

Caution should be exercised in interpreting these maps. Most of the maps included in this publication show the location of areas with high potential for the indicated environmental problem. That is, darker shaded polygons reflect a higher acreage-weighted average value for the indicator than lighter shaded polygons, reflecting greater potential problems. Neither the acreage affected nor the cost-effectiveness of enrolling cropland acres in these areas can be deduced from these maps. There is not necessarily a relationship between the amount of cropland and the index value. Nor is there necessarily a relationship between the cost of cropland and the index value where indices are weighted by population affected, since there tends to be less cropland and more expensive cropland near population centers.

Surface Water Quality

Indicators of surface water quality problems include sediment production, nitrogen runoff, and the presence or absence of cropland near water bodies.

Potential Sediment Production

Potential sediment production is the fraction of water-caused soil erosion that reaches water bodies. This measure modifies gross sheet and rill erosion using a delivery ratio calculated on the basis of the land cover and slope characteristics of the land adjacent to NRI sample points in each NRI polygon. Thus, even sample points with very high erosion rates can be buffered by the presence of flatter land in soil-retarding cover in an adjacent area. Because of reduced rainfall, this problem is largely absent west of the 100th meridian, except for pockets in the coastal valleys of California and Oregon.

Unweighted—Sediment production is concentrated along east and west slopes of the Appalachian mountains from eastern Pennsylvania to northern Georgia and from western Pennsylvania to northern Mississippi (Figure 1). It is also a problem in the Corn Belt, along the Missouri and Mississippi rivers in southern Iowa and northern Missouri and in southern Wisconsin and western Illinois.

Population weighted—Weighting by populations potentially affected in the watershed emphasizes densely populated areas in the eastern Pennsylvania and New Jersey, around the St. Louis area in Missouri, and along the lake plain near Chicago in Wisconsin and Illinois. Sparsely populated areas in southern Iowa and northern Missouri are deemphasized (Figure 2). Maximum population-weighted index values occur in Chester (PA) and Fairfax (VA) counties.

Potential Nitrogen Runoff

Potential nitrogen runoff depends on residual nitrogen above crop requirements and the infiltration and water-holding characteristics of the soils. In this measure, residual nitrogen applications above crop requirements and runoff are the key factors in a calculation of relative nitrogen loadings to surface waters, while watershed population proxies for potential damages.

Unweighted—Potential nitrogen runoff is concentrated in the Coastal Plain of the Southeast, Florida, and Gulf Coasts; along the western edge of the Michigan peninsula and the sandy outwash areas of central Wisconsin and Minnesota; in the claypans of eastern Texas; and in the eroded tablelands of central Nebraska (Figure 3). Contrast this map with complementary areas on the unweighted map of potential nitrogen leaching.
Population weighted—Areas with heavy loadings weighted by the population using groundwater include the Boston area, eastern Pennsylvania and New Jersey, the Potomac drainage, South Carolina's Edisto River drainage, south Florida, the Chattahoochee-Flint drainage in Georgia and Alabama, drainages around Detroit and Chicago, the Trinity River drainage around Houston-Galveston, southern California, and the immediate San Francisco Bay drainage (Figure 4). Relatively uniform unweighted nitrogen runoff values, when combined with population weights, reflect the population more than the underlying physical phenomenon. Maximum index values occur in San Bernardino (CA) and Middlesex (NJ) counties.

Potential for Filter Strips

Cropland within 100 feet of streams and lakes potentially contributes more pollutants to streams but could buffer water resources from upland runoff if planted to permanent vegetation. Cropland within 100 feet of water is assumed to be appropriate for conversion to permanent vegetative cover as filter strips. Wildlife benefits from filter strip development may occur, but are not accounted for here.

Unweighted—This index is fragmented in a wide scattering of polygons in many regions (Figure 5). The Corn Belt, Lake States, Northeast, and Appalachian regions have the highest index values, but scattered areas in the Dakotas, Montana, Idaho and eastern Oregon also rate highly, as well as the southern San Joaquin valley of California.
Population weighted—When weighted by watershed population, the index remains fragmented, rather than concentrated, but is clustered along both slopes of the Appalachian ridge (Figure 6). Population weighting emphasizes the Northeast, Florida, and areas around Santa Fe, New Mexico, Cheyenne, Wyoming, and coastal California. Maximum index values occur in Middlesex (NJ) and Ventura (CA) counties.

Groundwater Quality

Indicators of groundwater quality problems include potential for leaching pesticides and nitrates to groundwater supplies.

Potential Pesticide Leaching

Pesticide leaching is a function of both the characteristics of the pesticide and the leachability of the soils to which they are applied. This index is based on the GWVIP measure developed in Kellogg, et al. (1992).

Unweighted—The greatest physical potential for pesticide leaching occurs in the coastal plain and Piedmont soils of the Southeast and Mid-Atlantic region (Figure 7). Important, but lower potential exists along the Mississippi Valley from Illinois to Louisiana, and along the Ohio Valley in Indiana, Illinois, and Michigan. Central Nebraska and California's Central Valley also have important potential for pesticide leaching.
Population weighted—Weighting the index by the population using groundwater supplies emphasizes densely populated areas of eastern Pennsylvania and New Jersey, the North Carolina coastal plain, Florida, Gulf coast Alabama, the Chicago area, Phoenix, and most of the Central Valley, southern California, and the coastal valleys (Figure 8). More sparsely populated areas or areas with less dependence on groundwater, such as northern Alabama and Georgia and western North and South Carolina, are deemphasized. The maximum value for pesticides occurs in Dade (FL) county.

Potential Nitrate Leaching

Nitrate leaching depends on the quantity of residual nitrogen above crop needs and the leachability of the soils to which it is applied. This index is based on the GWVIN measure developed in Kellogg, et al. (1992).

Unweighted—The greatest physical potential nitrate leaching targets scattered areas in the Southern coastal plain and the areas west of the Appalachian and Allegheny mountains, and irrigated areas in Arizona (Figure 9). Secondary areas are the Illinois and Ohio corn grain producing areas.
Population weighted—Weighting the index by the population using groundwater supplies emphasizes southern New England, eastern Pennsylvania, New Jersey, the Carolina and Gulf coastal plain, scattered areas around Lake Michigan, the Phoenix-Tucson area of Arizona, and California's southern Central Valley (Figure 10). The maximum value for nitrates is in Suffolk (NY) county.

Wildlife Habitat

Indicators of wildlife problems include potential for improvement of wildlife habitat and the presence of actual or potential habitat for species threatened or endangered by agricultural development.

Potential for Wildlife Habitat Improvement

The quality of wildlife habitat depends on the structure of vegetative cover at each site and the diversity of covers on surrounding sites. This index is derived from data collected in the 1982 NRI by SCS National biologist Carl Thomas. It measures general (non species-specific) changes in the habitat structure at the sample point, primarily in going from cropland to grass cover, and the diversity of land uses around the sample point. The more intensive the current crop production system (particularly in regard to winter cover) and the less monotonic the surrounding land use pattern, the higher the index. Concentrations include eastern North Carolina, northern Florida, the Louisiana delta, and scattering throughout the Southwest (Figure 11). Maximum index values occur in Union (PA) and Adams (NE) counties. There is no population-weighted version of this map.

Species Threatened and Endangered (T&E) by Agricultural Development

This index is based on counts of T&E species by county from FWS listings indicating agriculture development as a contributor to the T&E status. Concentrations are in Florida, California, southern Arizona, Nevada, water resources developments along the Tennessee river in Tennessee and Alabama, a stepping-stone pattern along the flyway of the whooping crane in Texas, Nebraska, and the Dakotas, and in south central Missouri (Figure 12). Maximum index values occur in Highland and Polk (FL) counties. There is no population-weighted version of this map.

Soil Erosion

Indicators of problems associated with soil erosion include potential loss of soil productivity and potential for offsite problems caused by windblown soil.

Potential Soil Productivity Loss

Soil erosion rates, topsoil depths, and current soil productivity are key factors in soil productivity losses. Two factors are reflected in the unweighted version of this index: topsoil depth and the depth potentially lost to wind and water erosion each year. Thinner soils with higher erosion rates have fewer years of productivity remaining than thicker soils at lower erosion rates. A third economic factor is added in the weighted map, the value of the soil lost, represented by productivity-adjusted dryland cash rent. Thus the darkest areas on these maps have combinations of thin topsoil, high erosion rates, and valuable land.

Unweighted—Examining current erosion rates versus topsoil depth as a measure of potential productivity loss highlights problems with high erosion rates on thin soils in eastern Montana and Colorado, the Texas panhandle, South Dakota, eastern Nebraska, and along the east bank of the Mississippi Delta (Figure 13).
Value weighted—Weighting by cash rent, four major concentrations appear on the map, the largest being centered on Iowa, Illinois, and Missouri in the Corn Belt (Figure 14). A second concentration is the eastern bluffs of the Mississippi in western Kentucky, Tennessee, and Mississippi along the eastern edge of the Mississippi Delta. A third concentration is the irrigated cotton area of the Texas Panhandle, stretching up to the eastern edge of Colorado. The final concentration is a band in eastern Washington and Oregon around the Palouse wheat area. The maximum value occurs in Franklin (IN) county. Weighting by the cash rent value deemphasizes areas with less valuable soils in favor of erosion on the highly productive soils in the Corn Belt.

Potential Windblown Dust

This measure proxies for damages associated with windblown dust from wind erosion. Notice that basic data on wind erosion were not collected by SCS east of the 100th meridian except for states in which localized wind erosion problems were known to exist (Florida, the Eastern Shore, southern New Jersey, lake shores in Ohio, Indiana, and Michigan, and the loess soils of northeastern Arkansas).

Unweighted—Unweighted wind erosion is highest in the Rio Grande valley of Texas, the 1930's Dust Bowl of panhandle Texas, Oklahoma, southwestern Kansas, and eastern Colorado, eastern Montana, and scattered cropland areas of the Mountain states (Figure 15).
Population weighted—Severe wind erosion rates, high affected populations, or a combination of the two map heavily using this indicator. Notable concentrations include Dade County, Florida, southern Texas near Corpus Christi and Brownsville, the Texas panhandle southwest of Lubbock, the Denver and Colorado Springs areas, areas around Billings, Montana, California's southern Central Valley near Bakersfield-Fresno, and the eastern Washington area around Richland (Figure 16). The maximum index value occurs in Riverside (CA) county.

Other Indicators

Other indicators of interest include potential exposure to agricultural pesticides and potential for reducing flood damages through wetland restoration in floodplains.

Potential Flood Peak Reduction

With the Midwest floods fresh in the public mind, wetland restoration in floodplains to improve out-of-bank storage is topical. One aspect of floodplain management is the use and drainage of land within the 100-year floodplain, particularly land drained for crop production on former wetlands (hydric soils). A proxy for flood damages is achieved through weighting by the watershed population potentially affected.

Unweighted—Floodplain cropland is concentrated in the Missouri, Mississippi, Ohio and Red river valleys of North and South Dakota, Minnesota, Iowa, Wisconsin, Illinois, Missouri, and the Mississippi Delta (Figure 17).
Population weighted—Concentrations are in eastern North Carolina, the Ohio-Mississippi confluence and lower Mississippi, the Iowa-Cedar Rivers area, the Grand-Osage rivers in Missouri, the Red River of the North in Minnesota/North Dakota, and the watersheds of the Front Range in Colorado (Figure 18). Maximum index values occur in Somerset and Monmouth (NJ) counties.

Potential Pesticide Exposure

Exposure to pesticides is a function of the amount applied, and the persistence and toxicity of the material. This measure is based on the characteristics of the pesticides applied, measured by the ratio of soil half-life to acute oral toxicity to mammals. Thus, higher amounts applied of more toxic pesticides that persist in the soil longer are assumed to be more potentially harmful than smaller applications of less toxic pesticides that degrade more rapidly. Clusters occur in northern Maine, eastern North Carolina and southern Virginia, Florida, southern Georgia and eastern Alabama, southern Arizona, parts of California's Central Valley, and Idaho's Snake River valley

(Figure 19). The Corn Belt and northern Plains have relatively uniform and low scores. Maximum index values occur in Cameron (TX) and Autauga (AL) counties. There is no weighted version of this map.

Composite Environmental Benefits Index

Finally, geographic information systems capabilities allow the various indices to be combined into a composite index which gives an aggregate measure of agricultural environmental performance. Further, the composite index can be combined with data on other farm and economic factors. For example, the composite environmental index can be combined with the distribution of farm program payments to show areas with high relative environmental problems that also receive high levels of farm program payments. This kind of geographic analysis can be a useful way to assess how much existing programs can be redirected toward environmental objectives without alienating current program constituents.

Composite index

Summing across all the environmental indicators (weighted by affected populations or dryland cash rent) shows that the greatest environmental problems associated with agriculture are located in Long Island, eastern Pennsylvania and New Jersey, eastern North Carolina, Florida, Alabama, along the Chicago lake plain, in the Mississippi Delta region of Missouri, Tennessee, Arkansas, Louisiana, and Mississippi, in southern Texas, and in the south part of California's Central Valley and south central Arizona (Figure 20). Secondary areas with lower overall composite scores are in the Corn Belt, along the southern coastal plain, and in the Texas panhandle.

Farm and Economic Factors

A number of farm and economic factors are useful to put the environmental indicators into perspective.

Agricultural Diversity

Groupings of farms by county into regional farming clusters were constructed by Sommer and Hines (1991) and adapted for this publication. Agricultural enterprises that do not enjoy government income and price support programs include poultry; sheep, cattle, and other livestock; and vegetable, fruit, and nursery crops (Figure 21). Poultry production is clustered in a broad crescent through the Southeast from the Delmarva peninsula, through Virginia, North and South Carolina, Georgia, Alabama, Mississippi, and Arkansas. Sheep, cattle and other livestock occur in Virginia and West Virginia, from southern Missouri through east Texas, and in the Mountain states. Vegetable, fruit, and nursery production hugs the coasts, particularly the Northeast, Lake State, Florida, and the Pacific coast from Washington to southern California and Arizona.

Farm types with government income and price supports include corn, soybeans and hogs; dairy and other crops; cattle, wheat and other grains; tobacco; and cotton (Figure 22). The corn, soybean, hog complex is centered in the traditional Corn Belt, extending into western Kentucky and Tennessee. Dairy is important in the Lake states, the Northeast, and New England. Cattle and wheat dominate the northern Mountain states and the Great Plains, but are important in smaller clusters in eastern Virginia and North Carolina, in southern Georgia, and, in rice production in northeast Arkansas and along theTexas/Louisiana coast. Tobacco clusters in Kentucky, eastern Tennessee, Virginia, and North and South Carolina. Cotton is the important enterprise in the Mississippi Delta region, the Texas panhandle, and in Arizona and California.

Cropland productivity

Cropland productivity, as measured by net cash returns per acre of cropland, is highest in several coastal areas: areas where climate, soil, and irrigated conditions favor production of high-value crops; areas where proximity to population favors production of perishable crops; or where livestock operations can be integrated with extended cropping areas (Figure 23). The next rank of productive lands are centered in the Corn Belt, Lake, Northeastern, and Southern coastal plain.

Farm Program Payments

While many enterprises enjoy significant government support, the absolute dollar value of farm program payments is highest in the Corn Belt, the wheat areas of the northern and central Plains, Mississippi Delta, in the cotton areas of the Texas panhandle, Arizona and California's Central Valley, and in the wheat growing areas of eastern Washington and Oregon (Figure 24). These data reflect conditions in 1987, at the depth of the agricultural recession. Higher commodity prices since 1987 have reduced the absolute level of payments and the proportion of farm incomes from government payments. however, the geographic pattern of payments remains as shown.

Farm Program Payments and Environmental Indicators

Since 1985, conservation compliance, swampbuster, and sodbuster provisions of farm legislation have exerted positive leverage on environmental problems associated with agricultural production. The degree to which environmental concerns shown by the indicators mapped here can be dealt with through conservation compliance mechanisms depends on the coincidence between program payments and the problem conditions. Relatively little overlap exists between areas with high program payments per acre and the highest population-weighted composite environmental indicator (Figure 25). For scattered areas across Iowa and Illinois, Louisiana, coastal and panhandle Texas, Arizona, and the northern Central Valley, conservation compliance could leverage significant additional environmental gains. Moderate farm program payment levels are associated with the highest environmental problems in broader bands of the Southeastern coastal plain, the eastern Corn Belt and the Missouri and Mississippi Valleys, eastern Texas, and the Central Valley. Large parts of Florida, the Northeast, the Southeastern piedmont, Louisiana, and coastal California have high composite environmental scores, but little or no farm program payments with which to leverage changes in farm production practices. In these areas, environmental gains must be purchased with positive inducements, such as a green support program, or compelled through regulatory programs.

Large parts of the most intensively farmed areas of the country, including much of the Corn Belt and Great Plains, have lower farm program payments and less critical environmental problems, as measured by the population-weighted composite score.

Conclusions

What can we learn from these maps about designing programs to address agriculture's environmental problems? Four lessons seem clear.

Different objectives affect different areas. The intensity of different environmental problems associated with agricultural production is not distributed uniformly across the country generally, nor is it uniformly distributed across areas with significant agricultural production. This results from the joint distributions of intensive agricultural production practices and vulnerable resource conditions. The design of a green support payment program must take into account the varying distributions of environmental problems by specifically addressing which problems or mix of problems the program aims to solve and what mechanisms are selected to provide incentives or leverage.

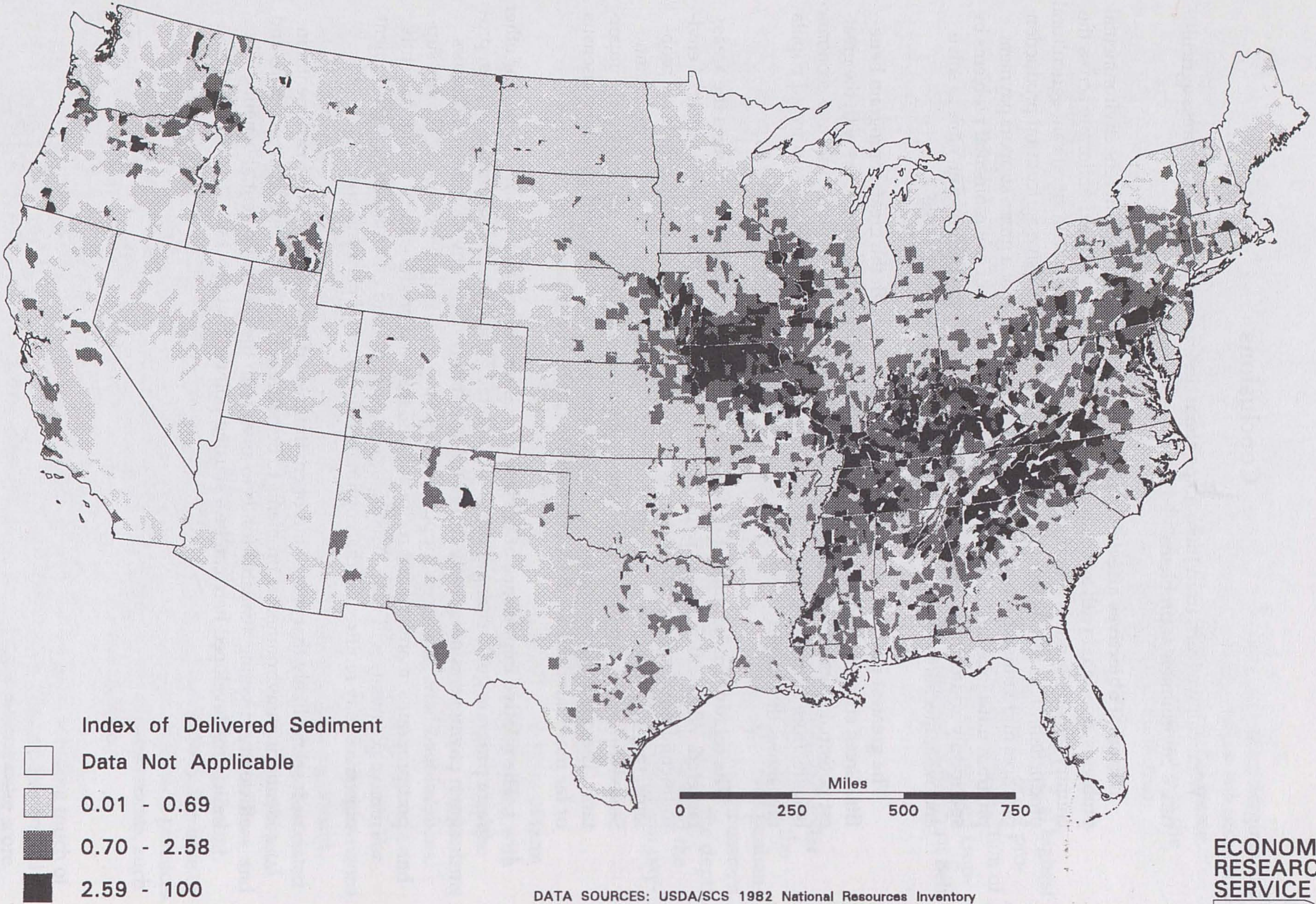
The greatest physical problems may not coincide with the greatest program benefits. Green support program design must choose between targeting areas with the greatest potential physical problems and areas with the greatest potential social and economic benefits from addressing physical problems. Weighting an indicator by affected population shows that these two targeting strategies do not always coincide.

The relative importance of different environmental problems changes the areas targeted. While environmental indicators can show the distributions of potential environmental problems, and they can be combined to identify areas with multiple problems, they cannot show which environmental problems are more or less important. Stated differently, problems with equally high index values may not be equally important. The relative importance of different problems is a subject for political consensus or far more intensive analysis of risks than can be encompassed here.

The relative importance of environmental objectives and income support or other farm program goals changes the areas targeted. The current distribution of farm program payments is not greatly correlated with many of the environmental indicators developed here. If a green support payment program supplants existing income support programs, many current recipients will lose and producers that do not currently receive payments will gain. Mixing income support and environmental improvement objectives may require less than optimal environmental performance.

It seems likely that some kind of environmental indicators will be instrumental in identifying environmental problems to be addressed through new farm programs and efficiently targeting available funds to areas with the greatest potential benefits. The indicators developed here can be a starting point in that process.

Figure 1
Potential Sediment Production
Sheet and rill erosion delivered to streams and lakes



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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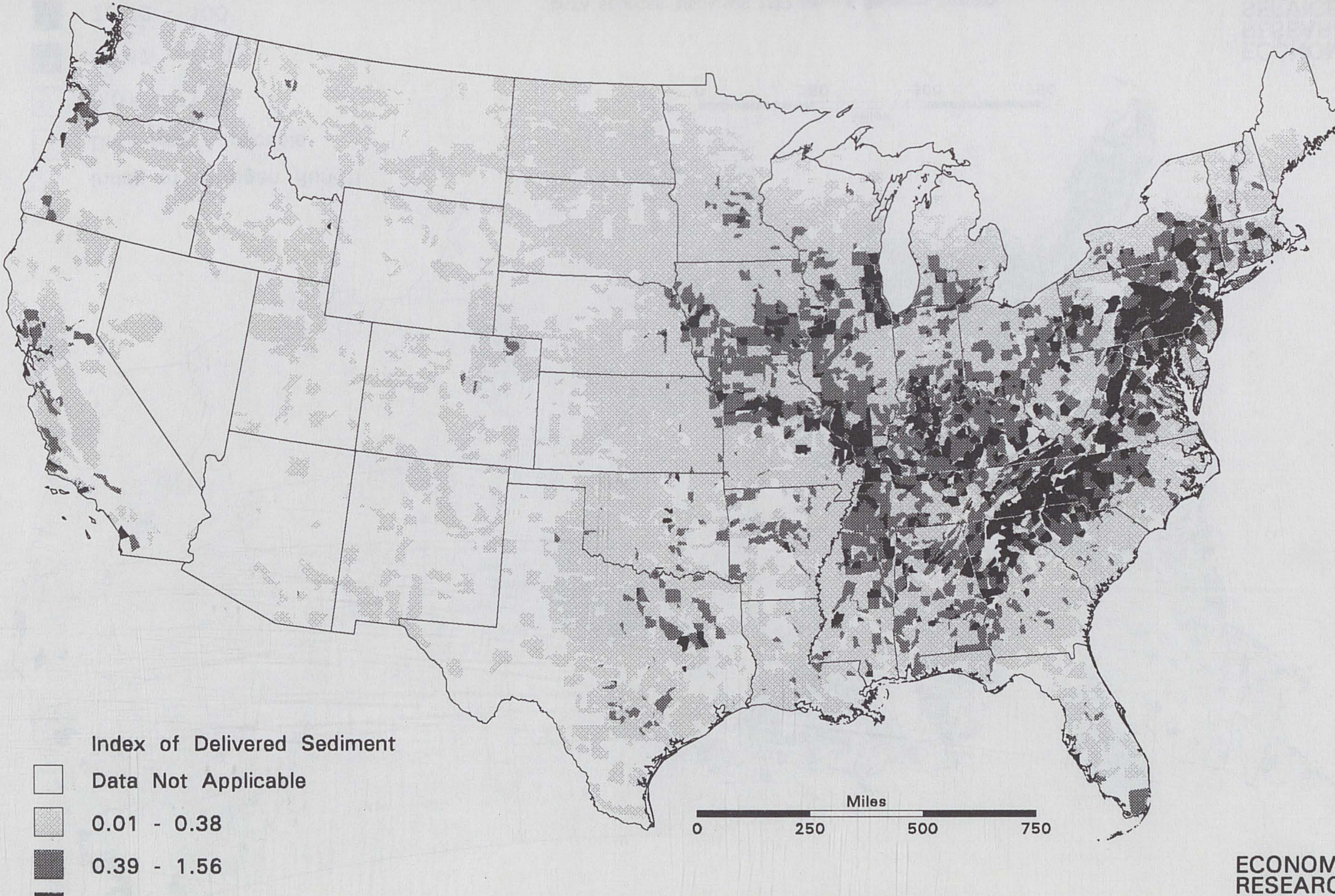
Figure 2
Potential Sediment Production
Sheet and rill erosion delivered to streams and lakes, weighted by watershed population



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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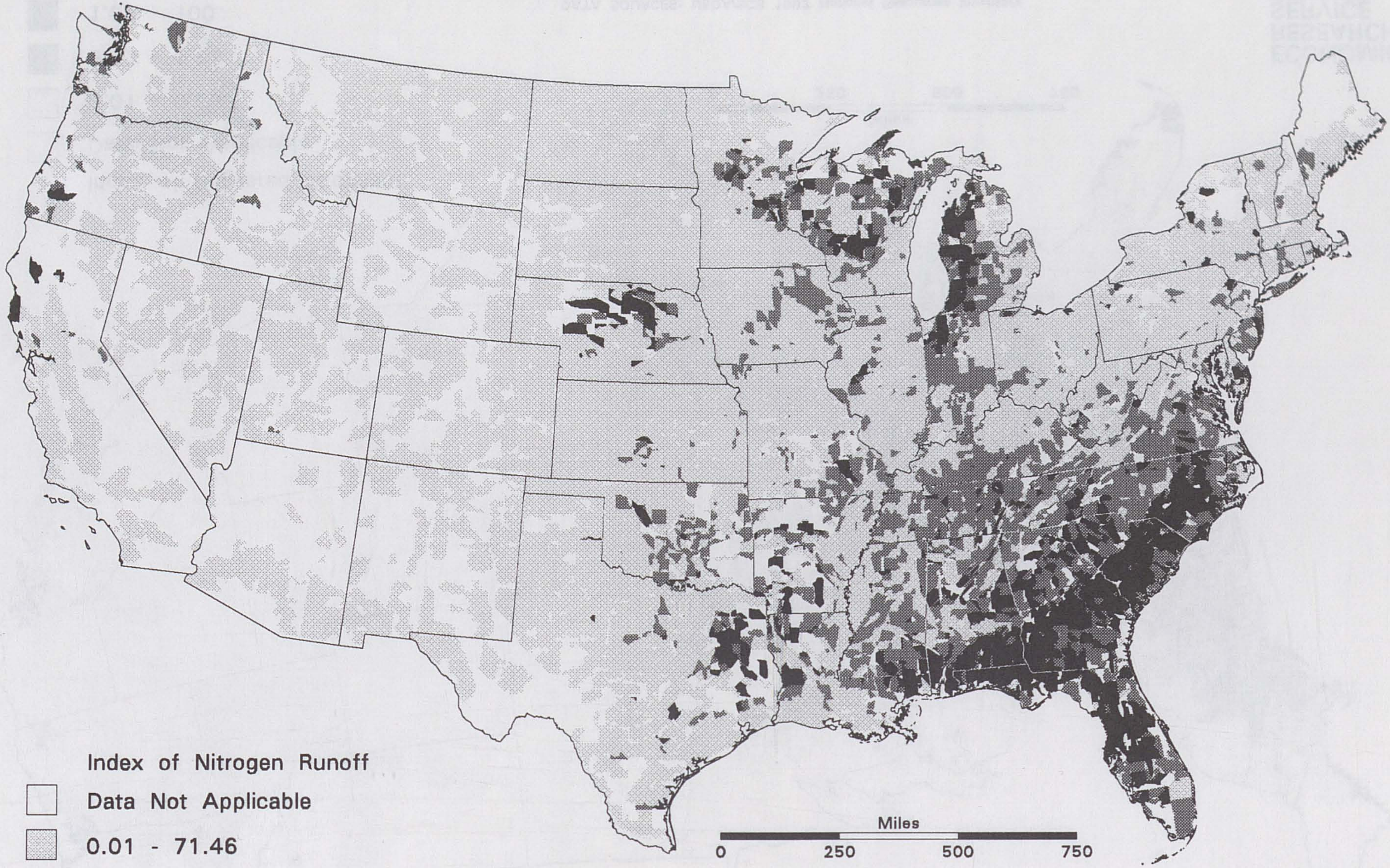
Figure 3
Potential Nitrogen Runoff
Residual nitrogen runoff to surface waters



Index of Nitrogen Runoff

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- 71.47 - 76.11
- 76.12 - 100

DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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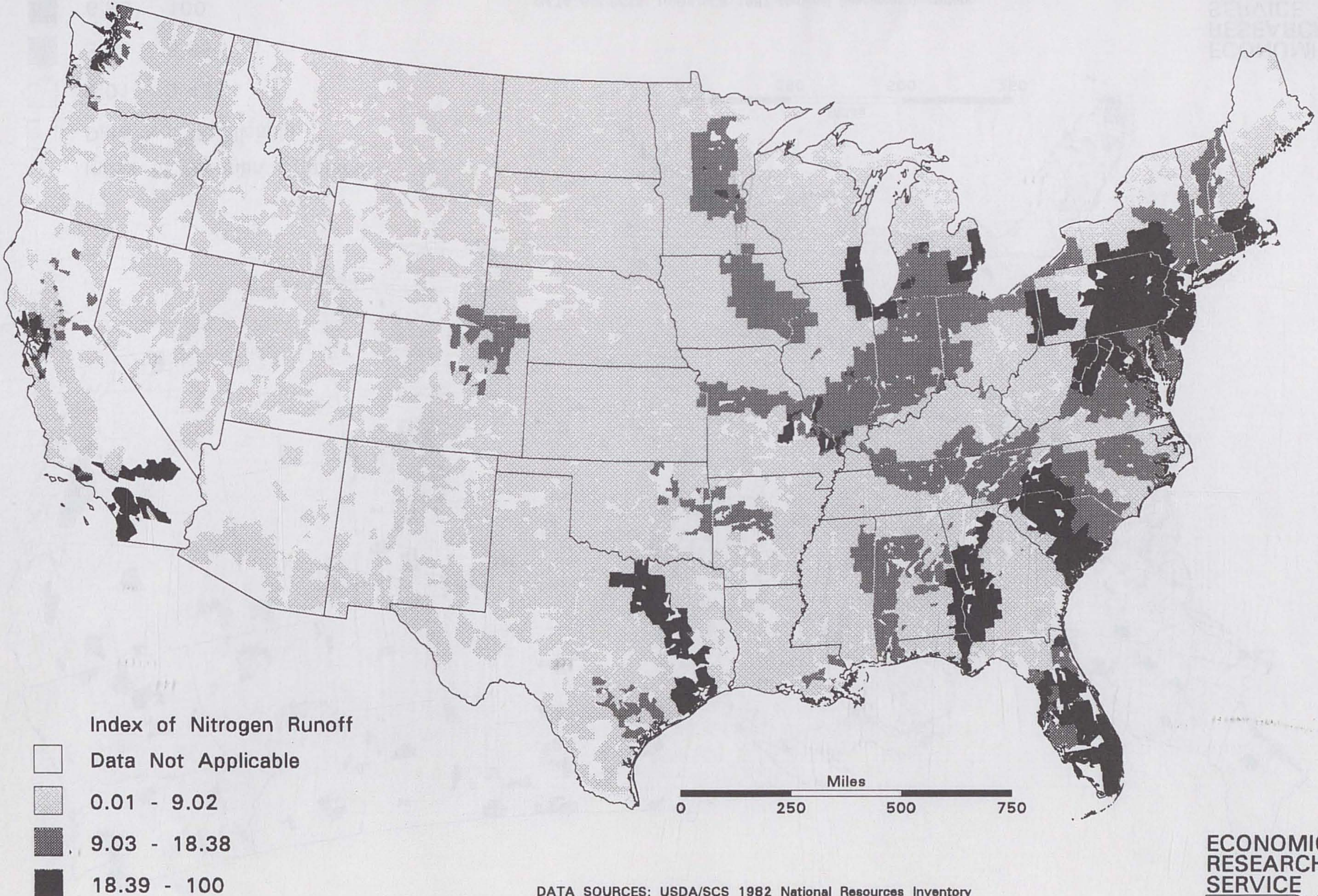
Figure 4
Potential Nitrogen Runoff
Residual nitrogen runoff to surface waters, weighted by watershed population



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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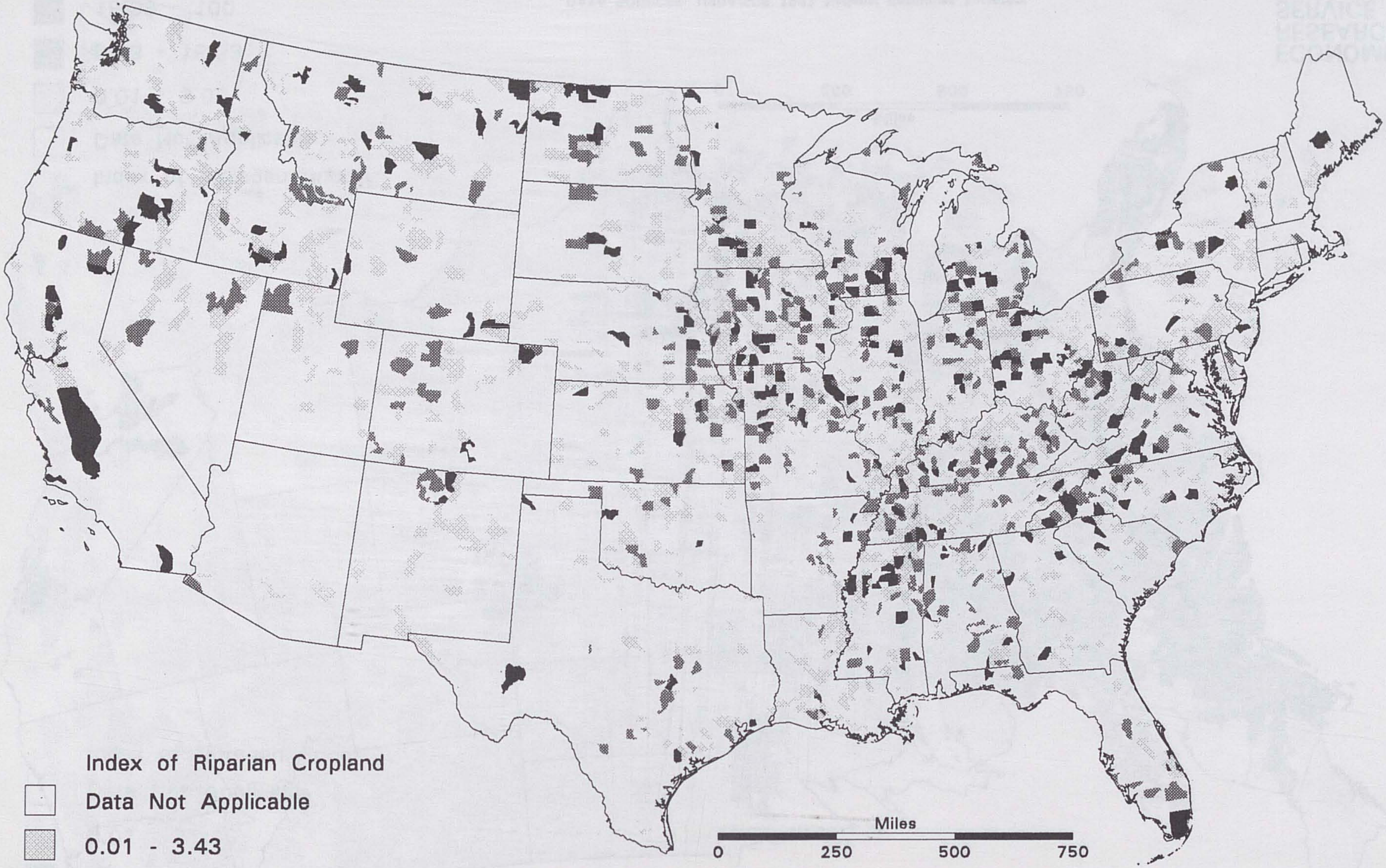
Figure 5
Potential for Filter Strips
Cropland within 100 feet of streams and lakes



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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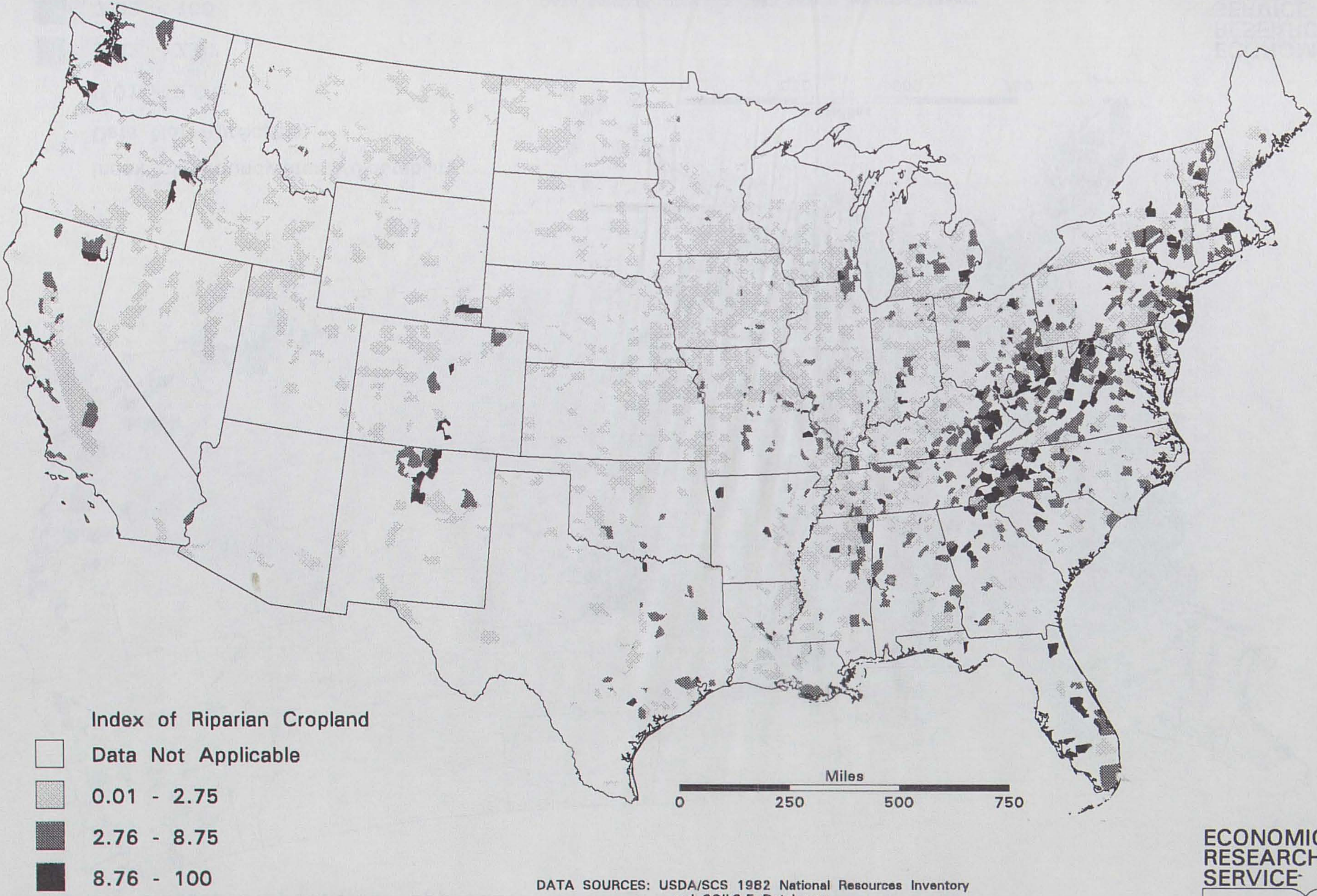
Figure 6

Potential for Filter Strips

Cropland within 100 feet of streams and lakes, weighted by watershed population



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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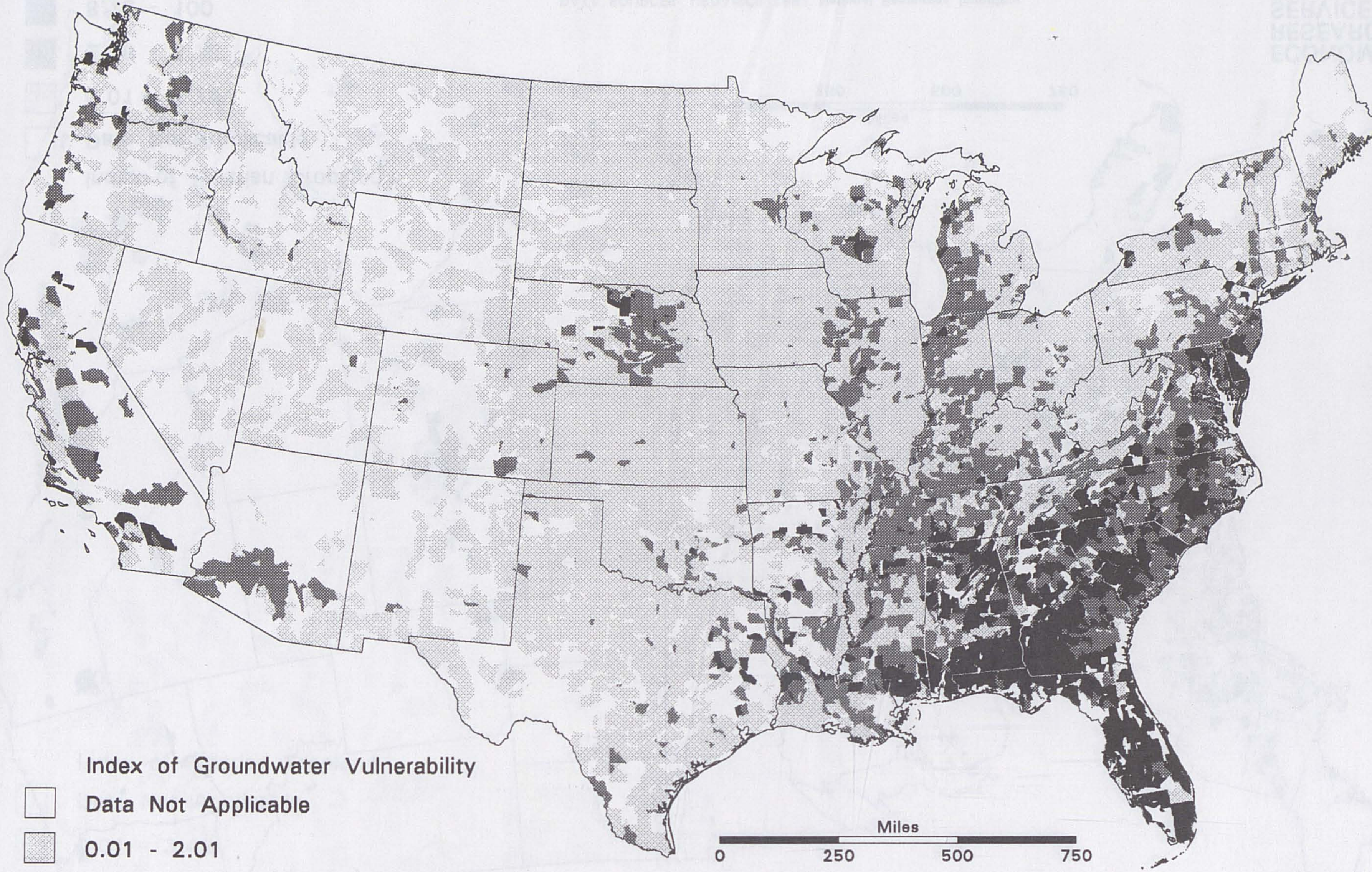
Figure 7
Potential Pesticide Leaching
Leaching classes of pesticides applied to leaching classes of cropland soils



Index of Groundwater Vulnerability

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- 2.02 - 7.07
- 7.08 - 100

DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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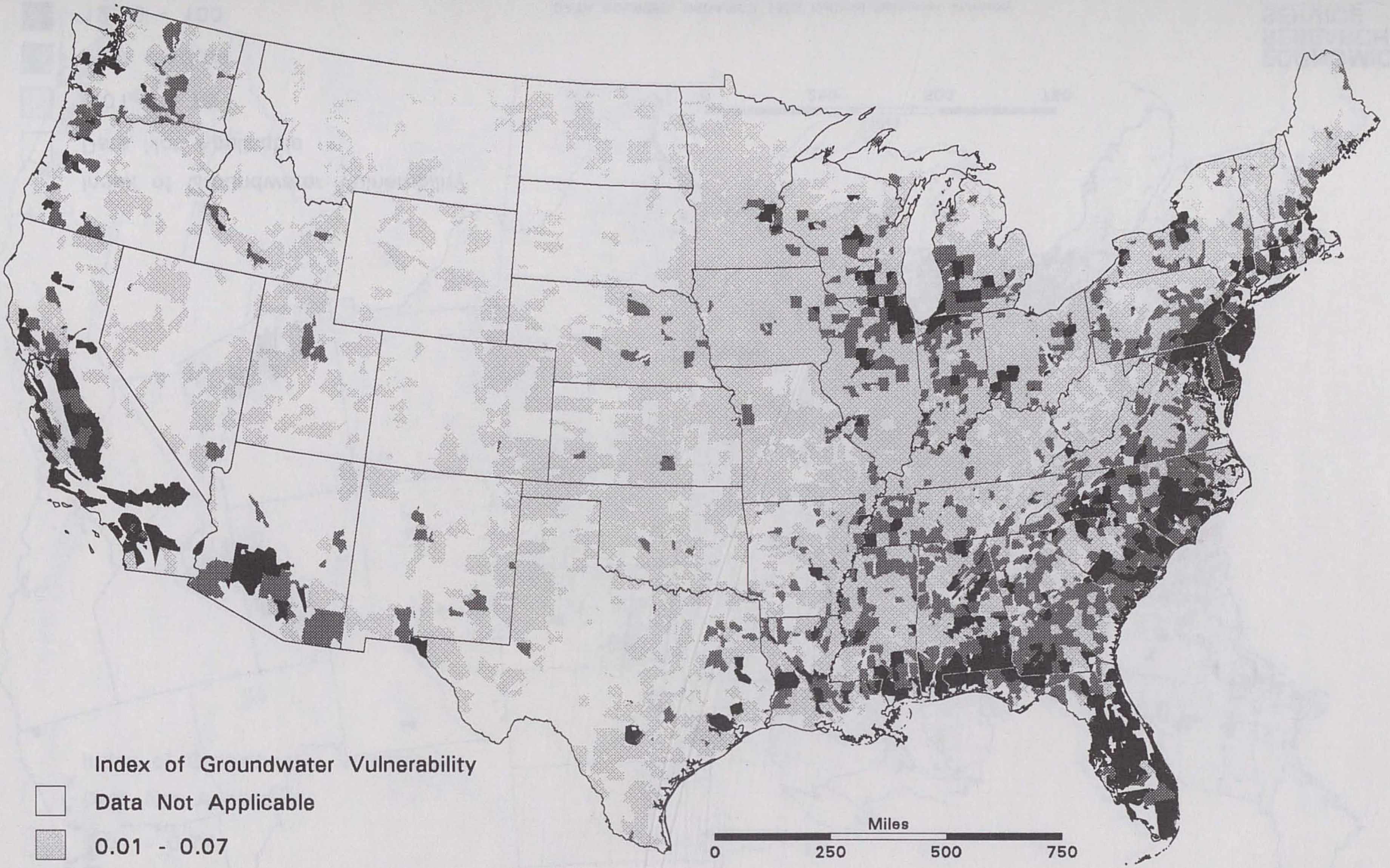
Figure 8
Potential Pesticide Leaching
Leaching classes of pesticides applied to leaching classes of cropland soils, weighted by population



Index of Groundwater Vulnerability

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- 0.28 - 100

DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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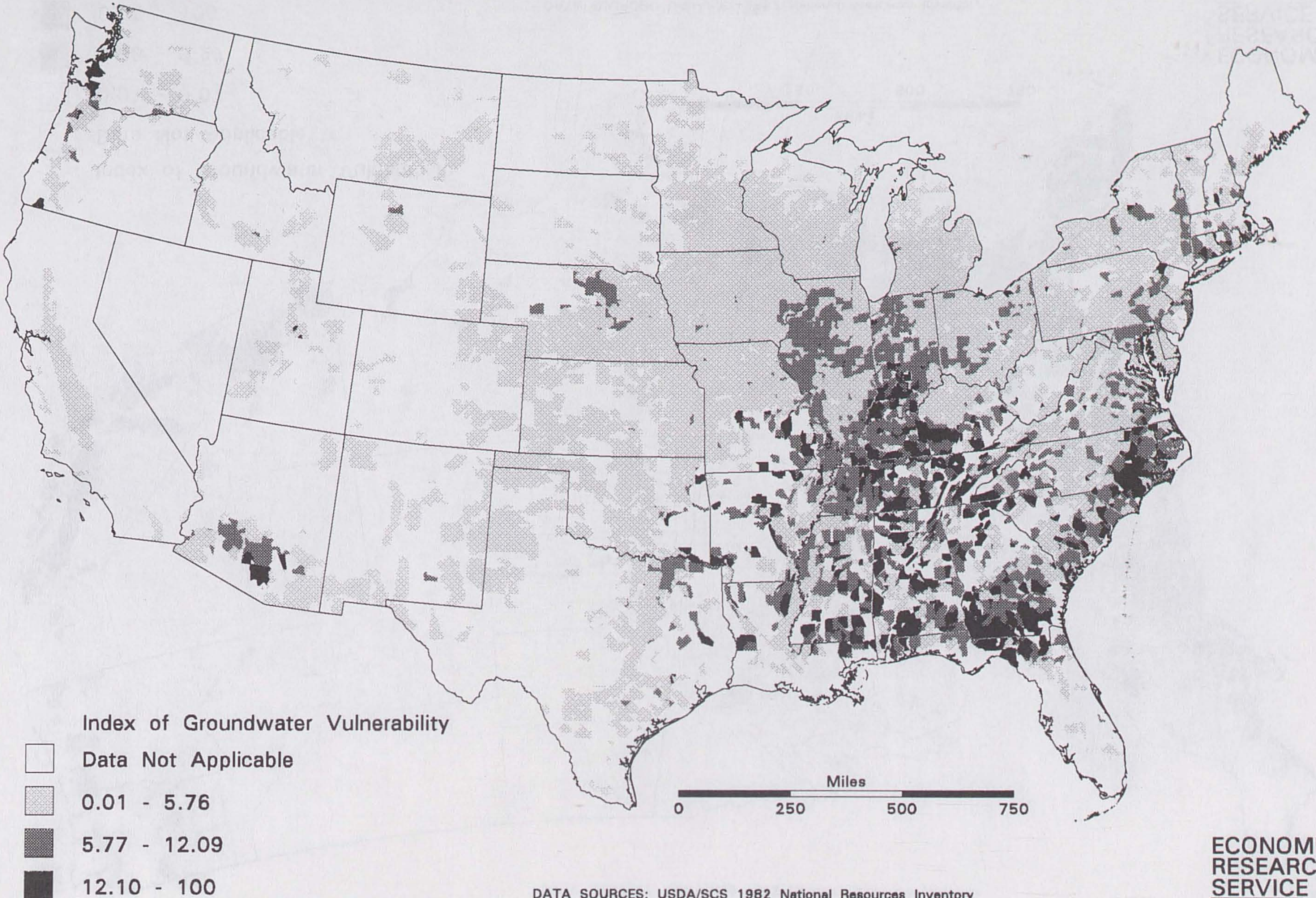
Figure 9
Potential Nitrate Leaching
Residual nitrogen applied to leaching classes of cropland soils



DATA SOURCES: USDA/SCS 1982 National Resources Inventory
and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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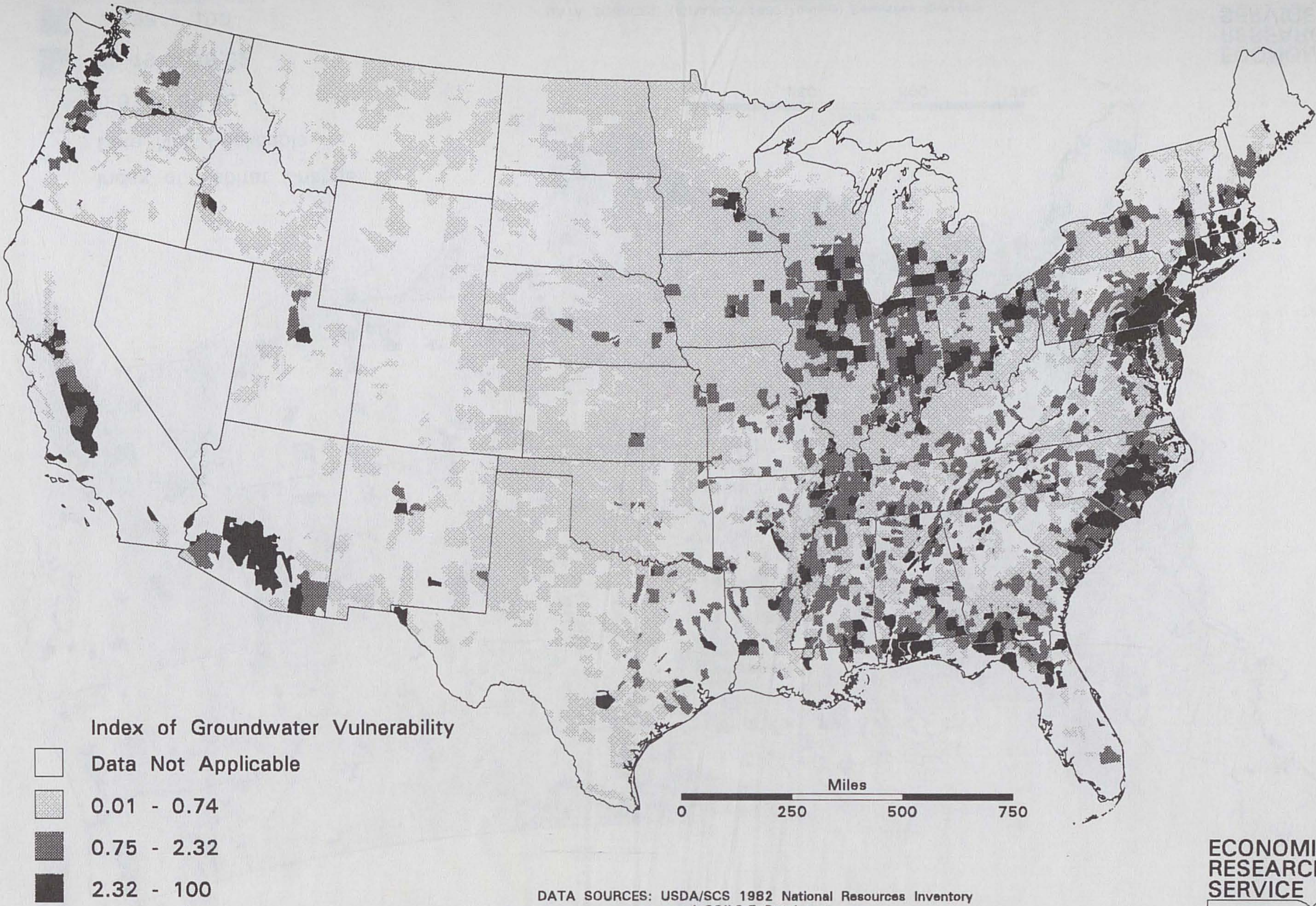
Figure 10
Potential Nitrate Leaching
Residual nitrogen applied to leaching classes of cropland, weighted by population using groundwater



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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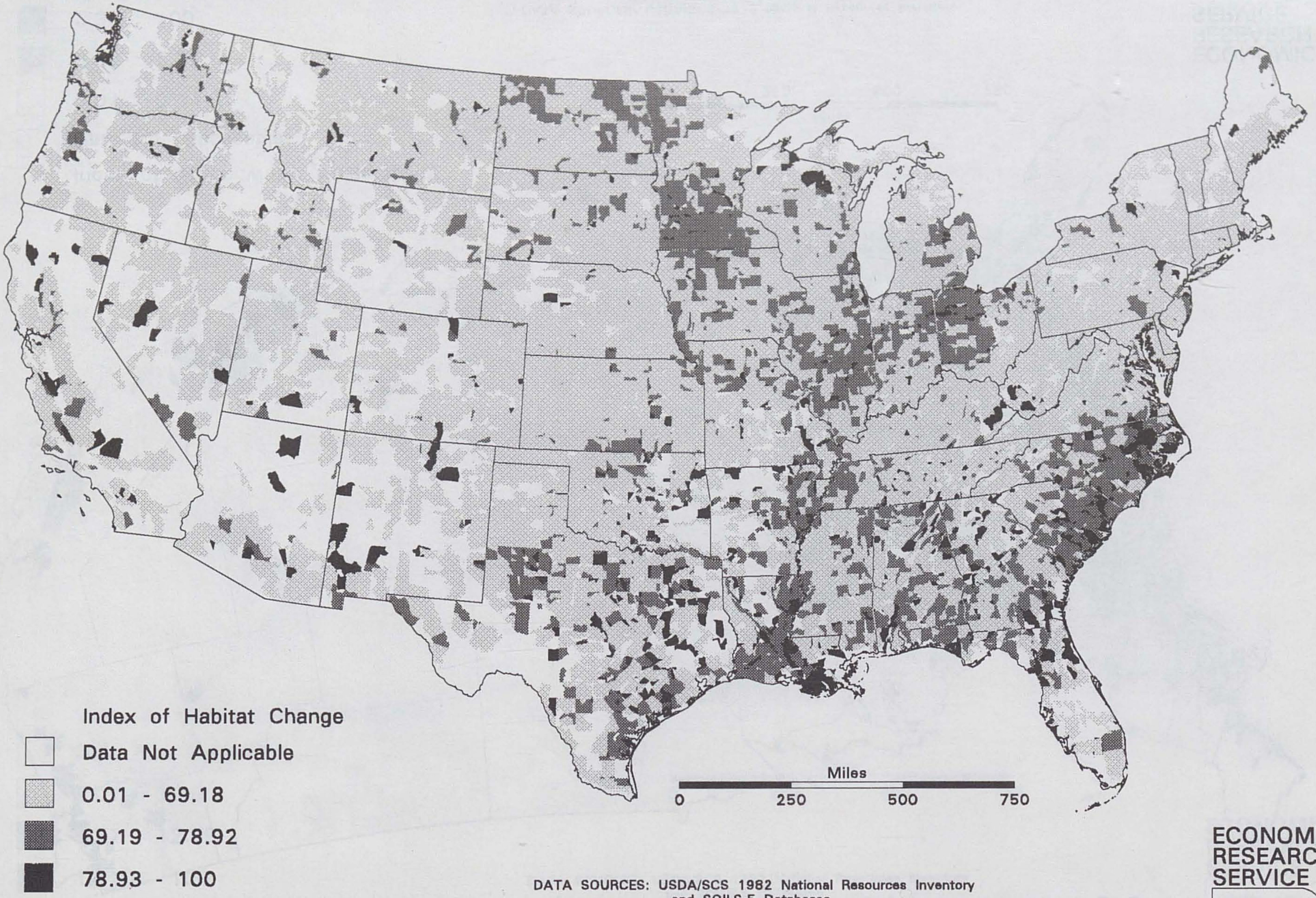
Figure 11
Potential for Wildlife Habitat Improvement
Changes in habitat structure and diversity on cropland



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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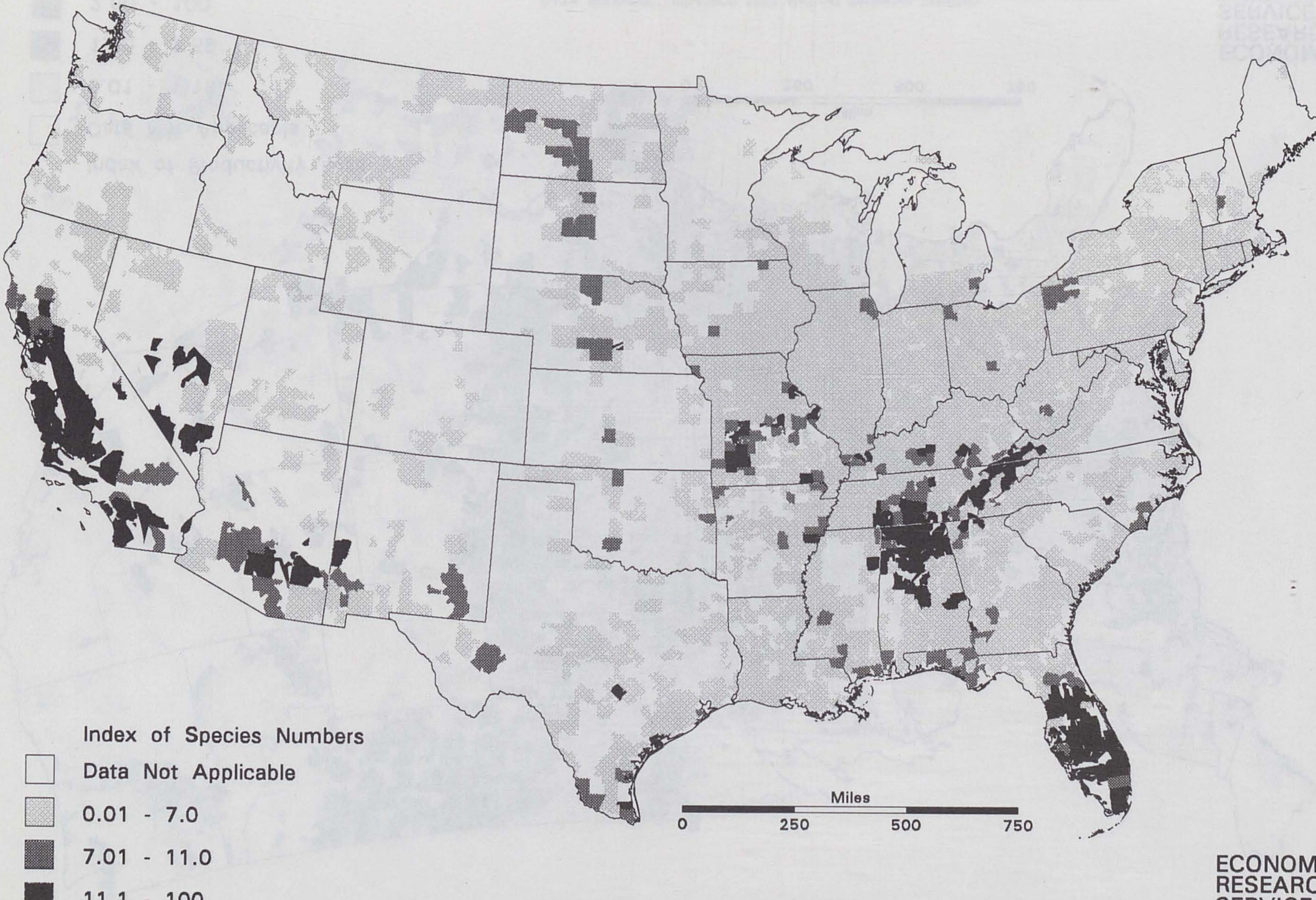
Figure 12

Species Threatened and Endangered by Agricultural Development

Number of Species



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

ECONOMIC RESEARCH SERVICE

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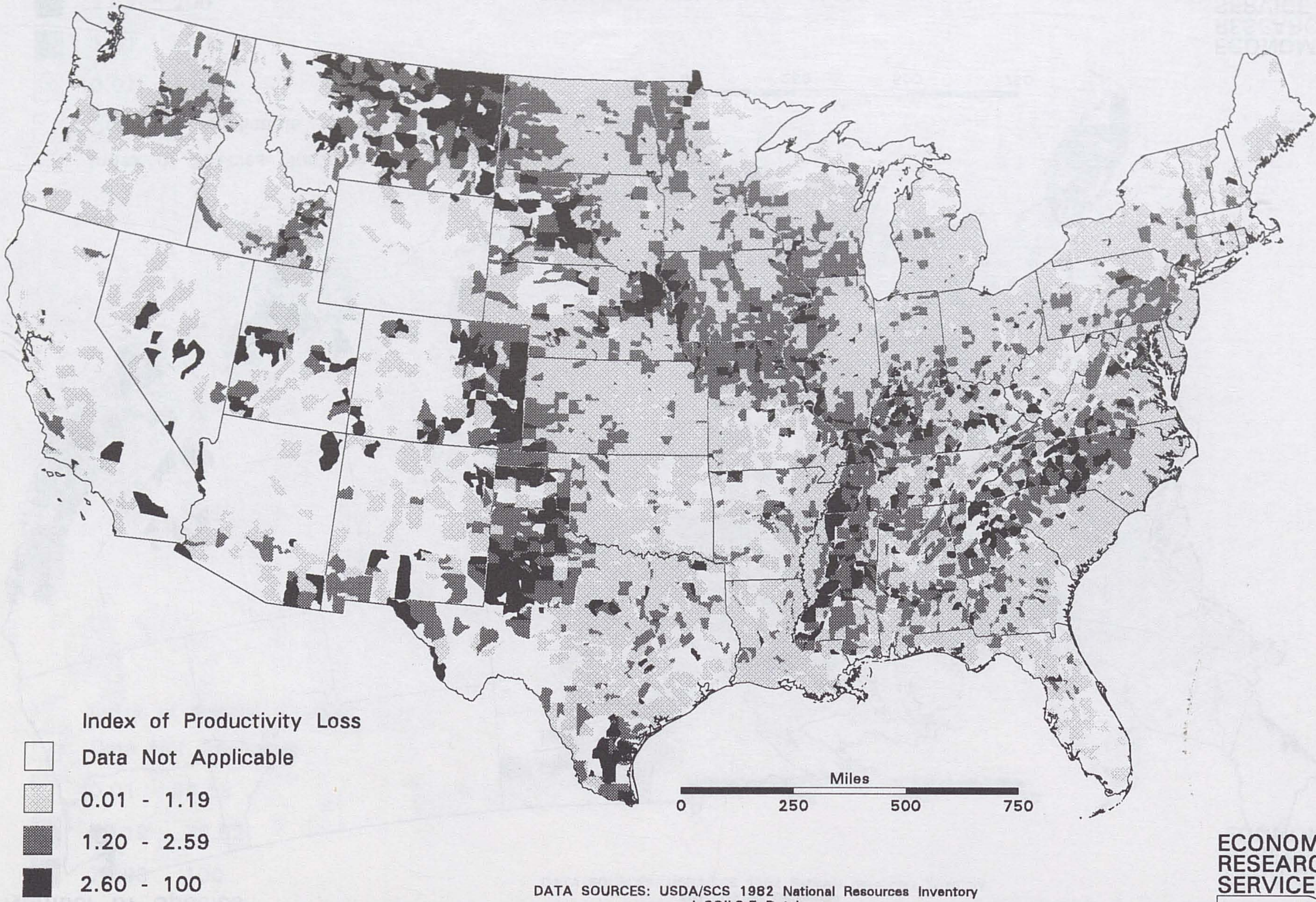
Figure 13

Potential Soil Productivity Loss

Inverse of years of topsoil depth remaining at current erosion rates



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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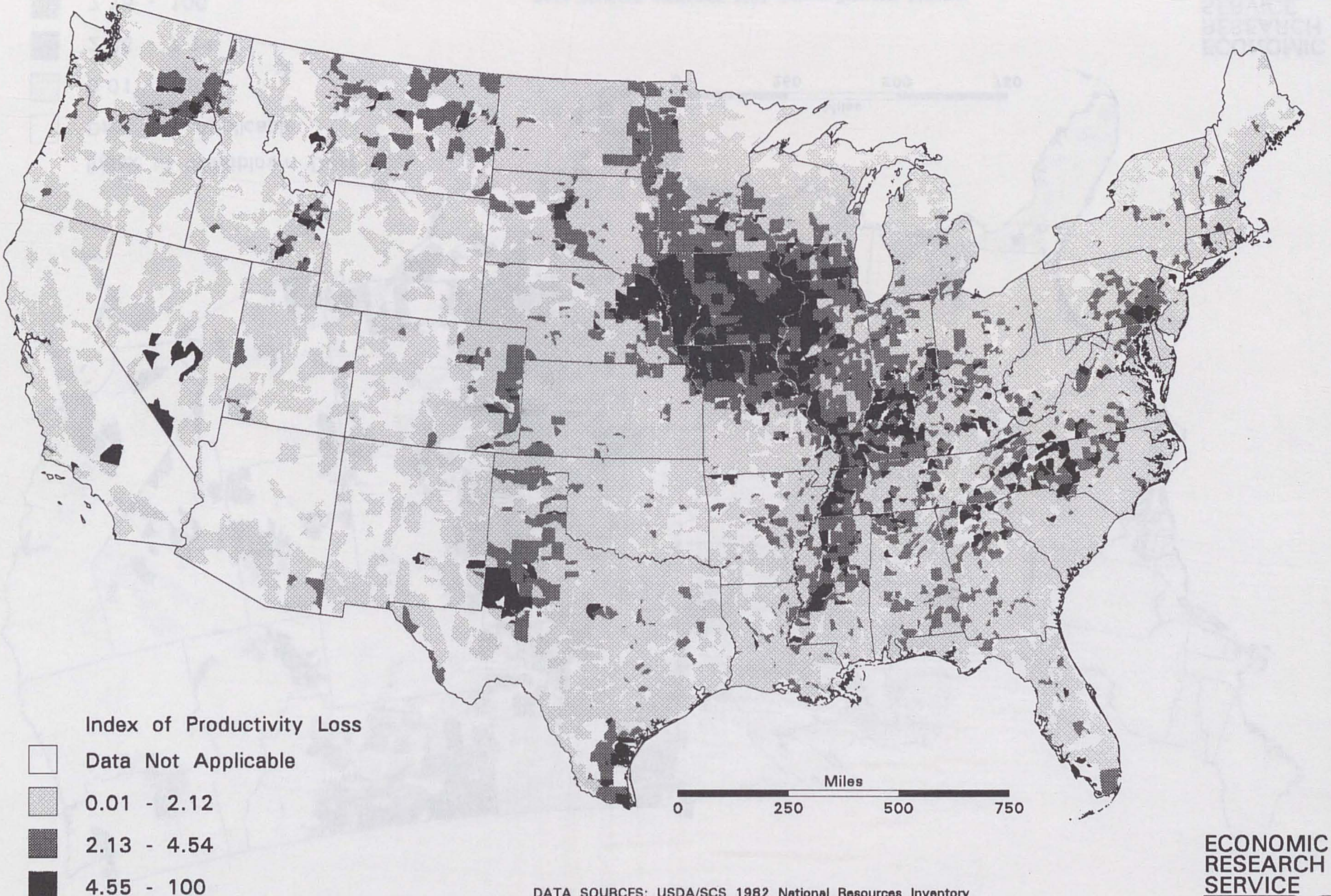
Figure 14
Potential Soil Productivity Loss
Dryland cash rent divided by years of topsoil depth remaining at current erosion rates



DATA SOURCES: USDA/SCS 1982 National Resources Inventory
and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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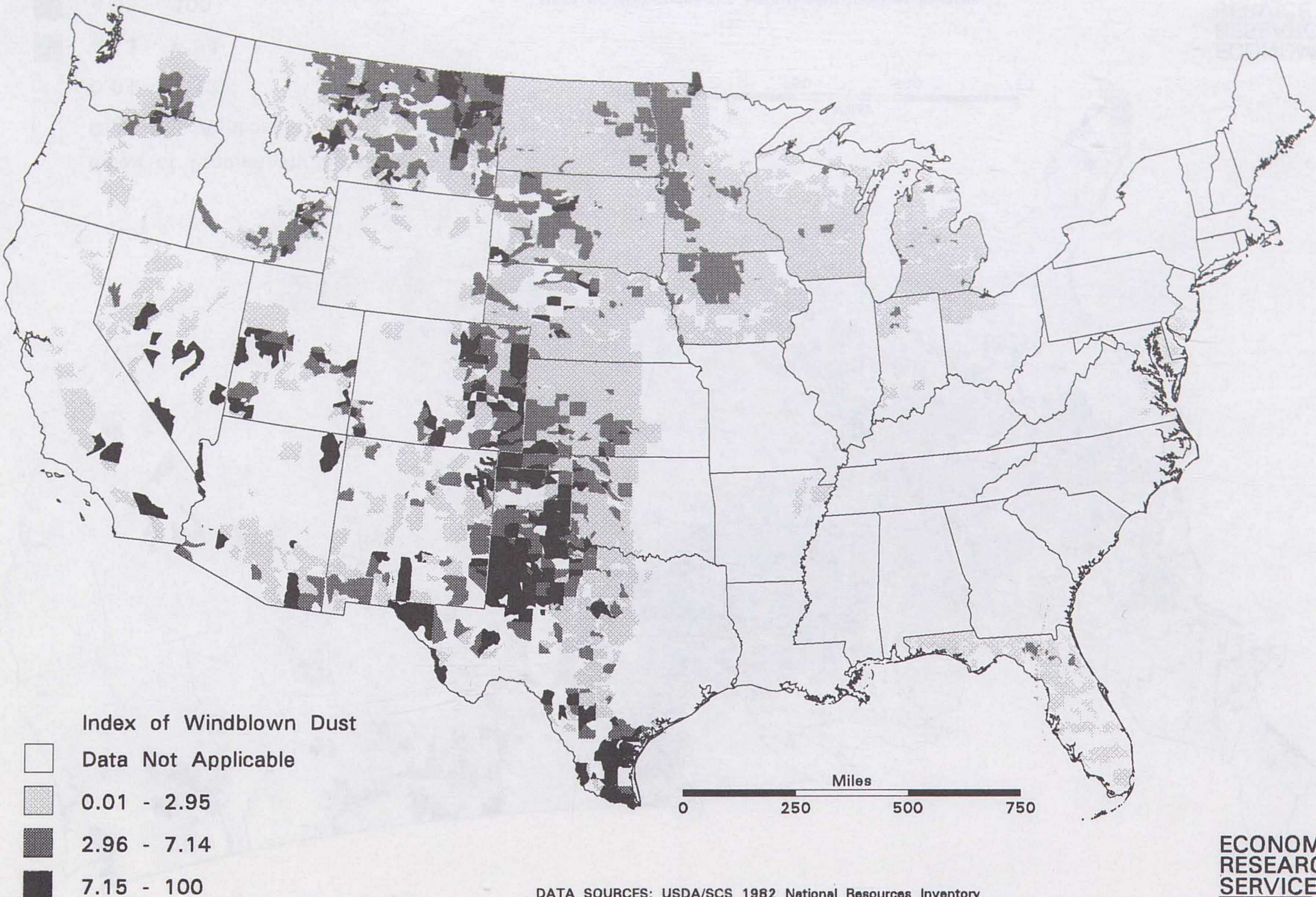
Map Created: 07/01/94 3:58 PM

Figure 15
Potential Windblown Dust
Wind erosion



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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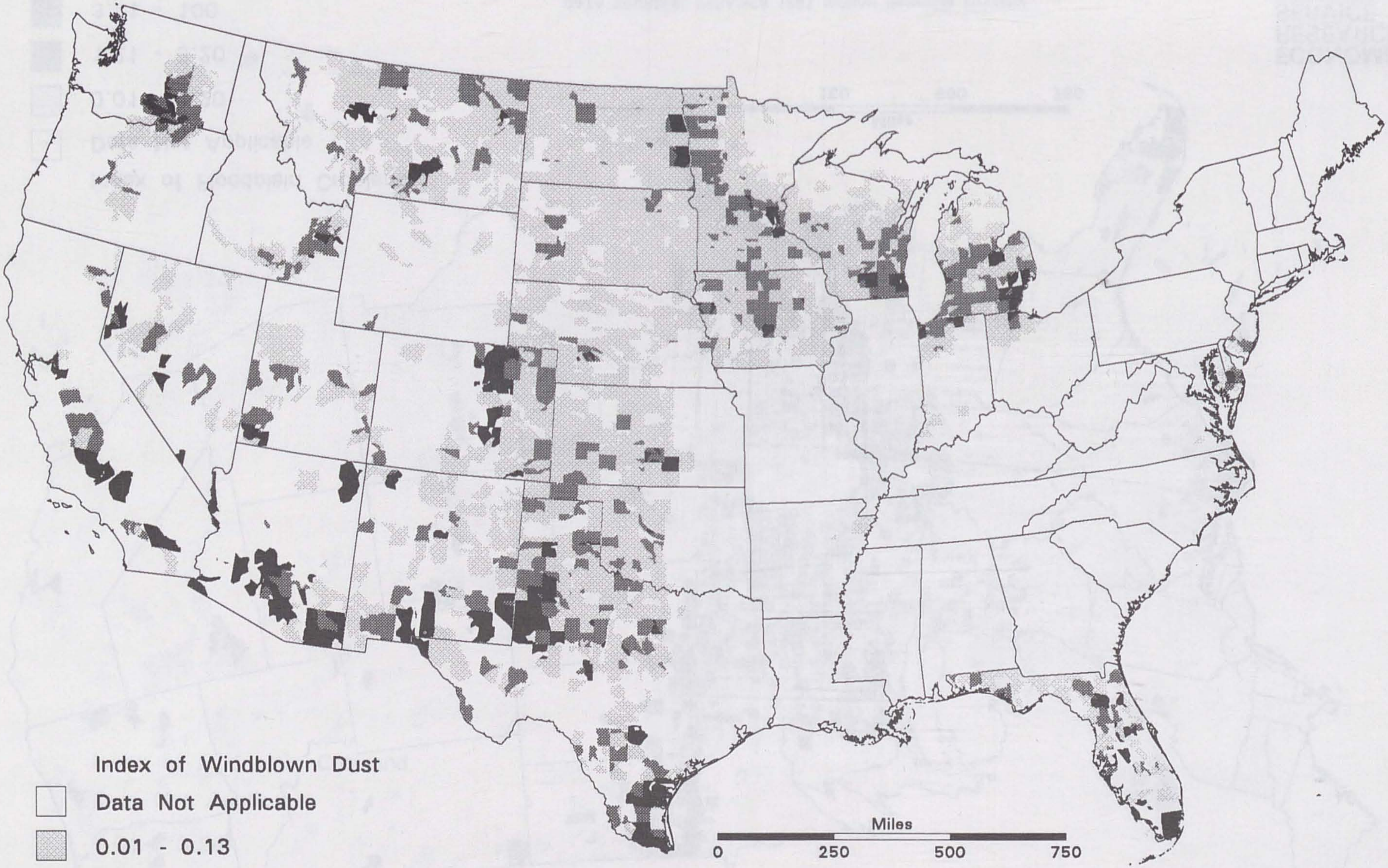
Map Created: 07/01/94 3:58 PM

Figure 16
Potential Windblown Dust
Wind erosion, weighted by county population



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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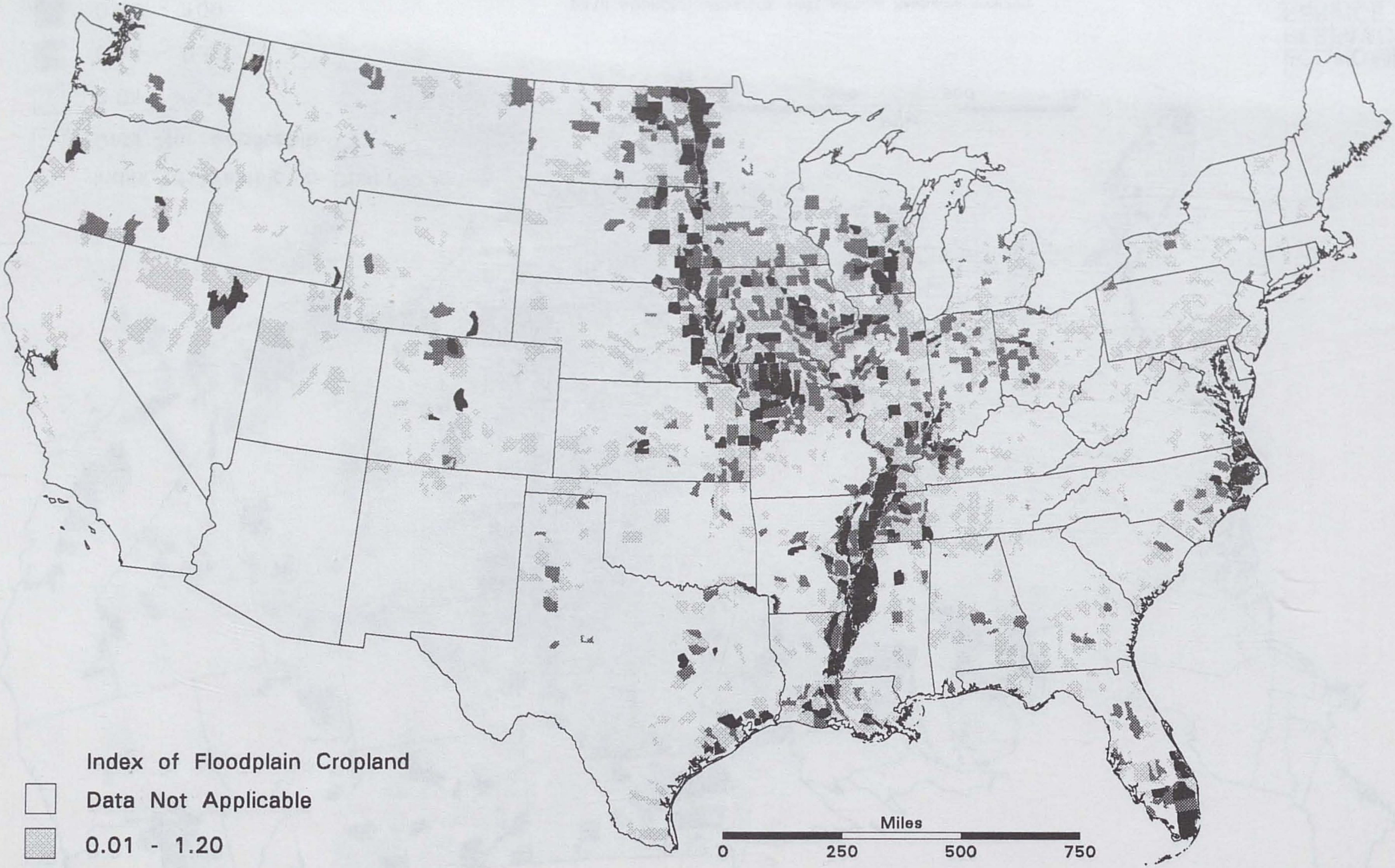
Figure 17
Potential for Flood Peak Reduction
Cropland on hydric soils in the 100-year floodplain



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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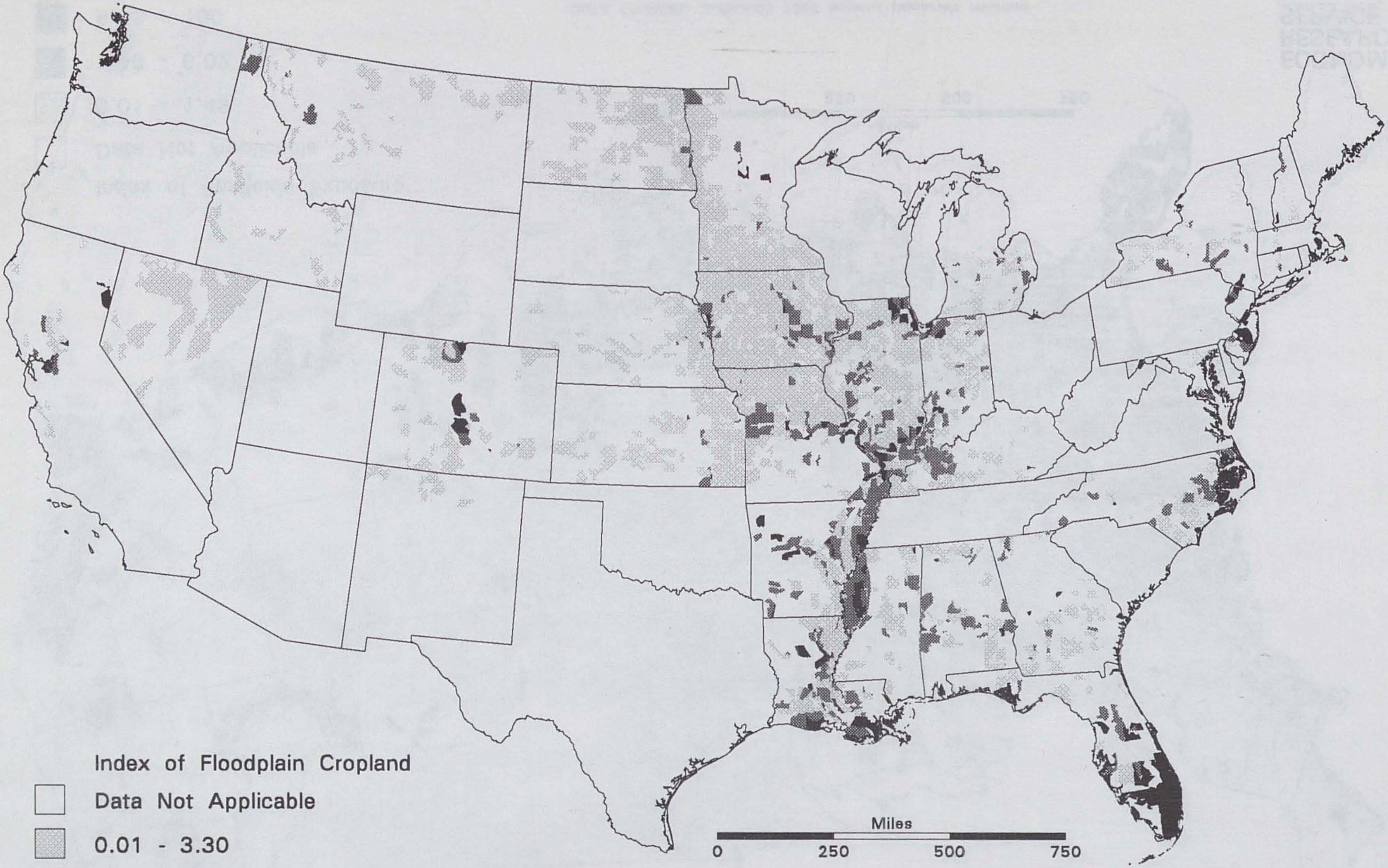
Figure 18

Potential for Flood Peak Reduction

Cropland on hydric soils in the 100-year floodplain, weighted by watershed population



Index of Floodplain Cropland

- Data Not Applicable
- 0.01 - 3.30
- 3.31 - 10.02
- 10.02 - 100

DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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Figure 19
Potential Pesticide Exposure
Pounds of active ingredient applied, weighted by persistence and toxicity

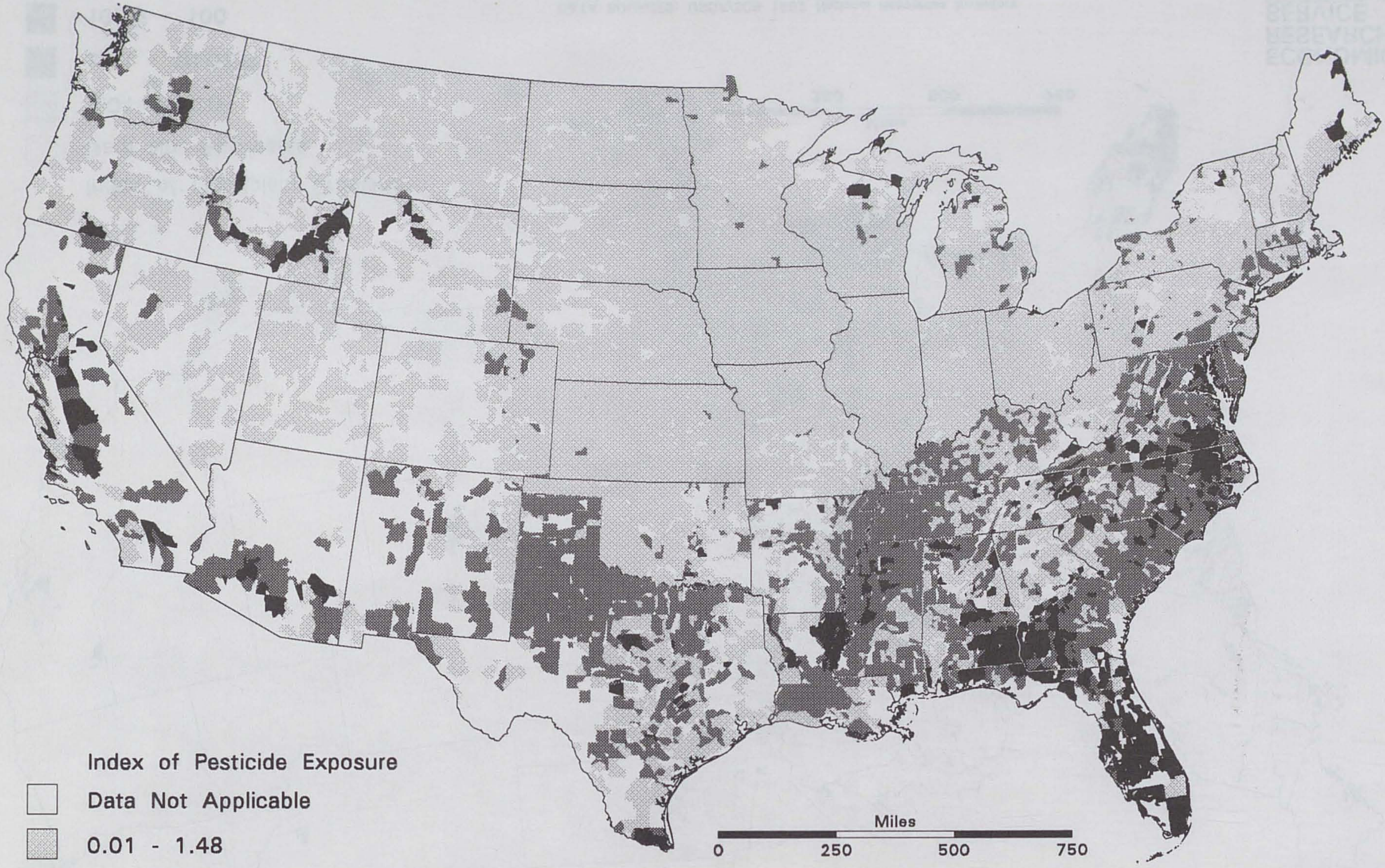
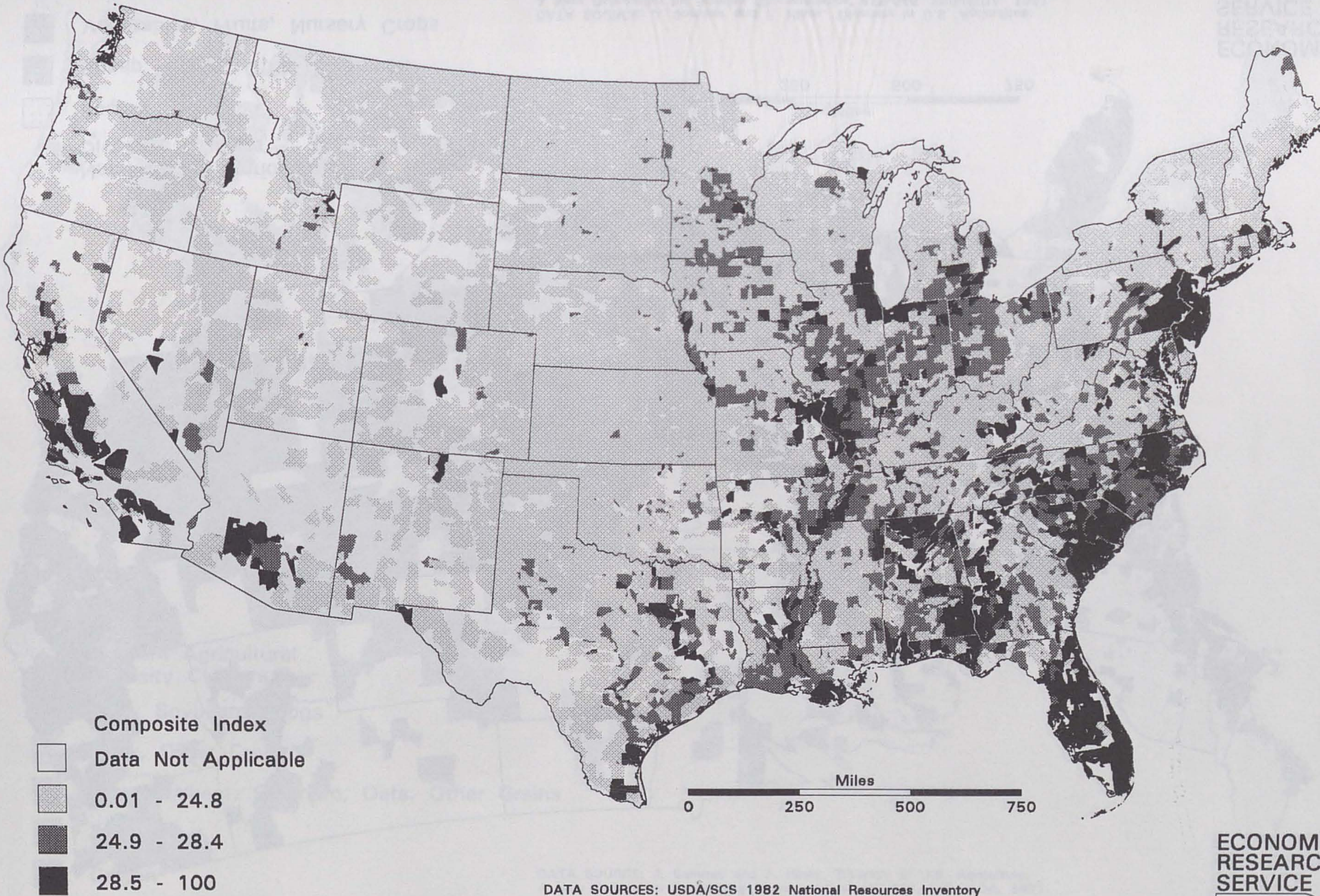


Figure 20
Composite Environmental Benefits Index
All weighted indices, summed and normalized



DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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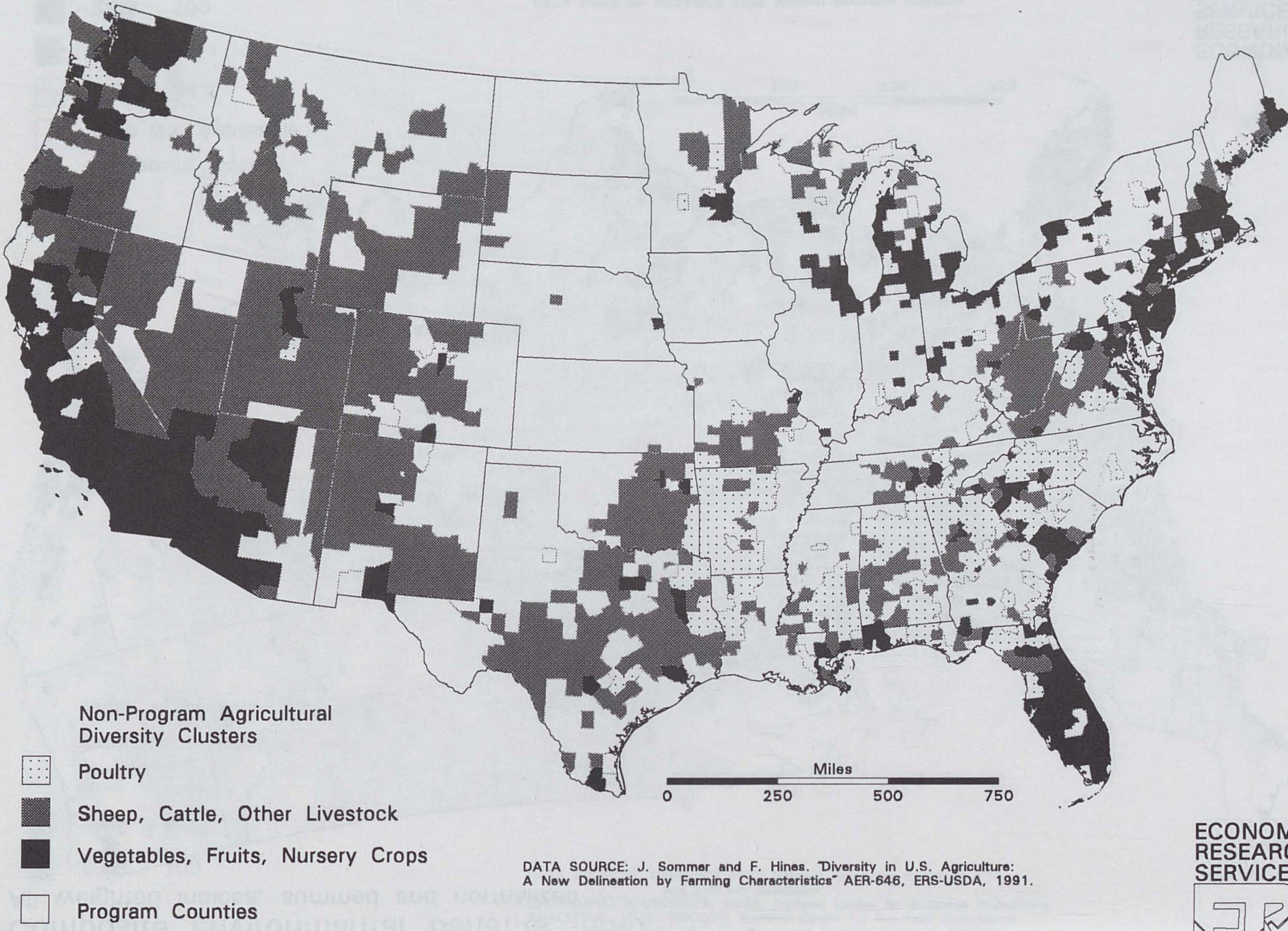
Map Created: 07/01/94 4:10 PM

Figure 21

Agricultural Diversity, Non-Program Crop Farm Types



DATA SOURCE: J. Sommer and F. Hines. "Diversity in U.S. Agriculture: A New Delineation by Farming Characteristics" AER-646, ERS-USDA, 1991.

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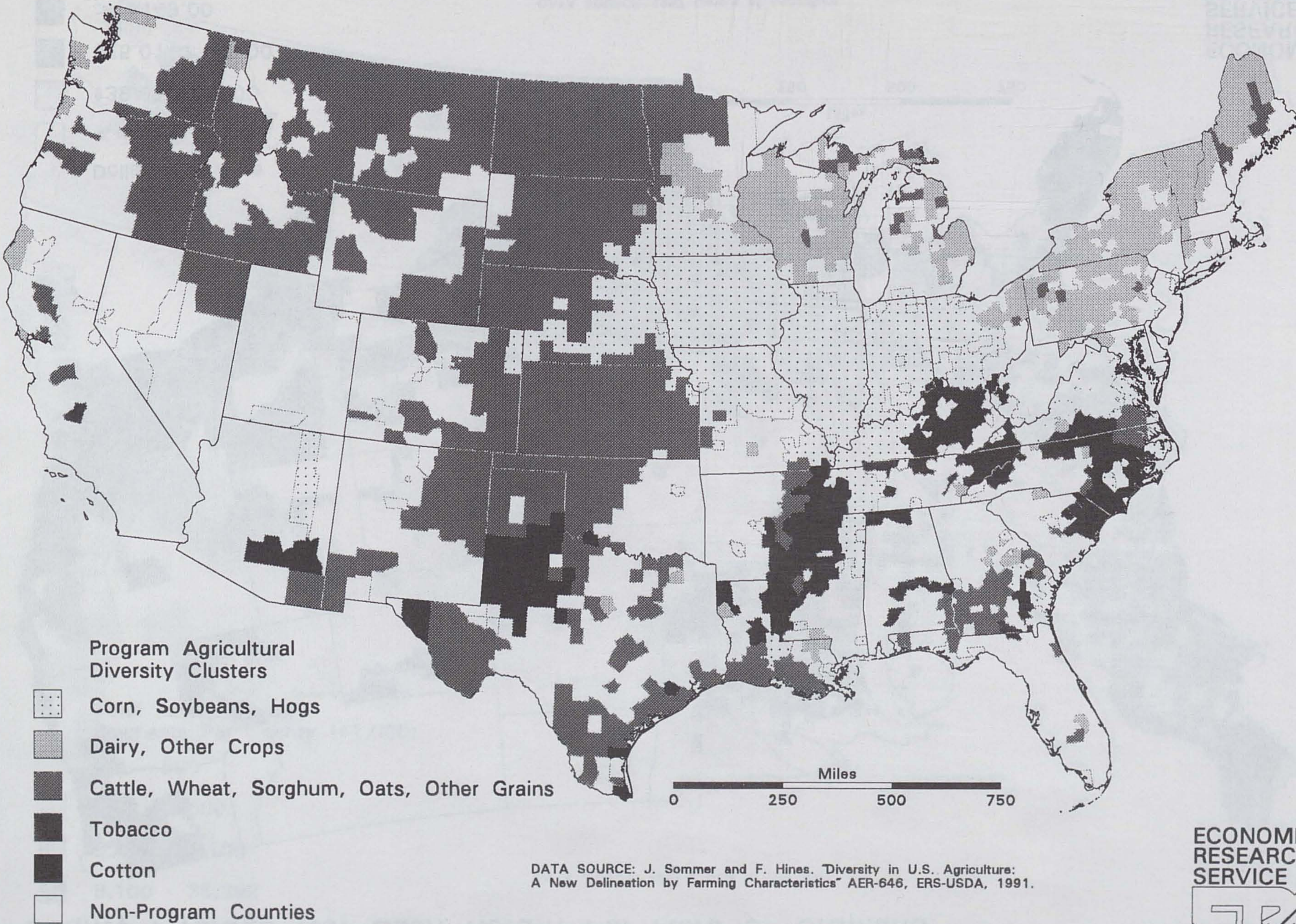
Figure 22
Agricultural Diversity, Program Crop Farm Types



DATA SOURCE: J. Sommer and F. Hines. "Diversity in U.S. Agriculture: A New Delineation by Farming Characteristics" AER-646, ERS-USDA, 1991.

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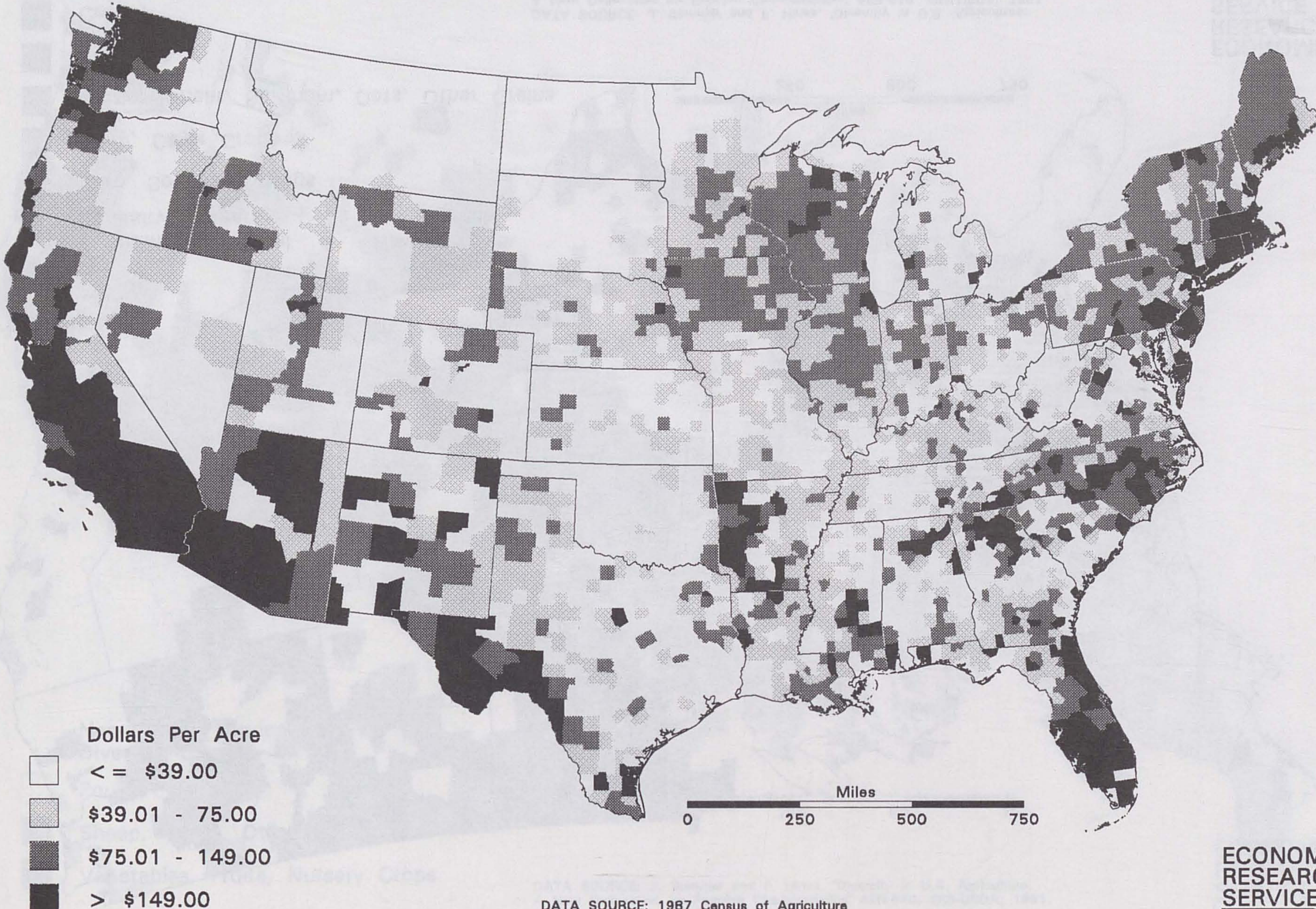
Figure 23
County Average Net Cash Return Per Acre of Cropland



DATA SOURCE: 1987 Census of Agriculture

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Figure 24
Farm Program Payments

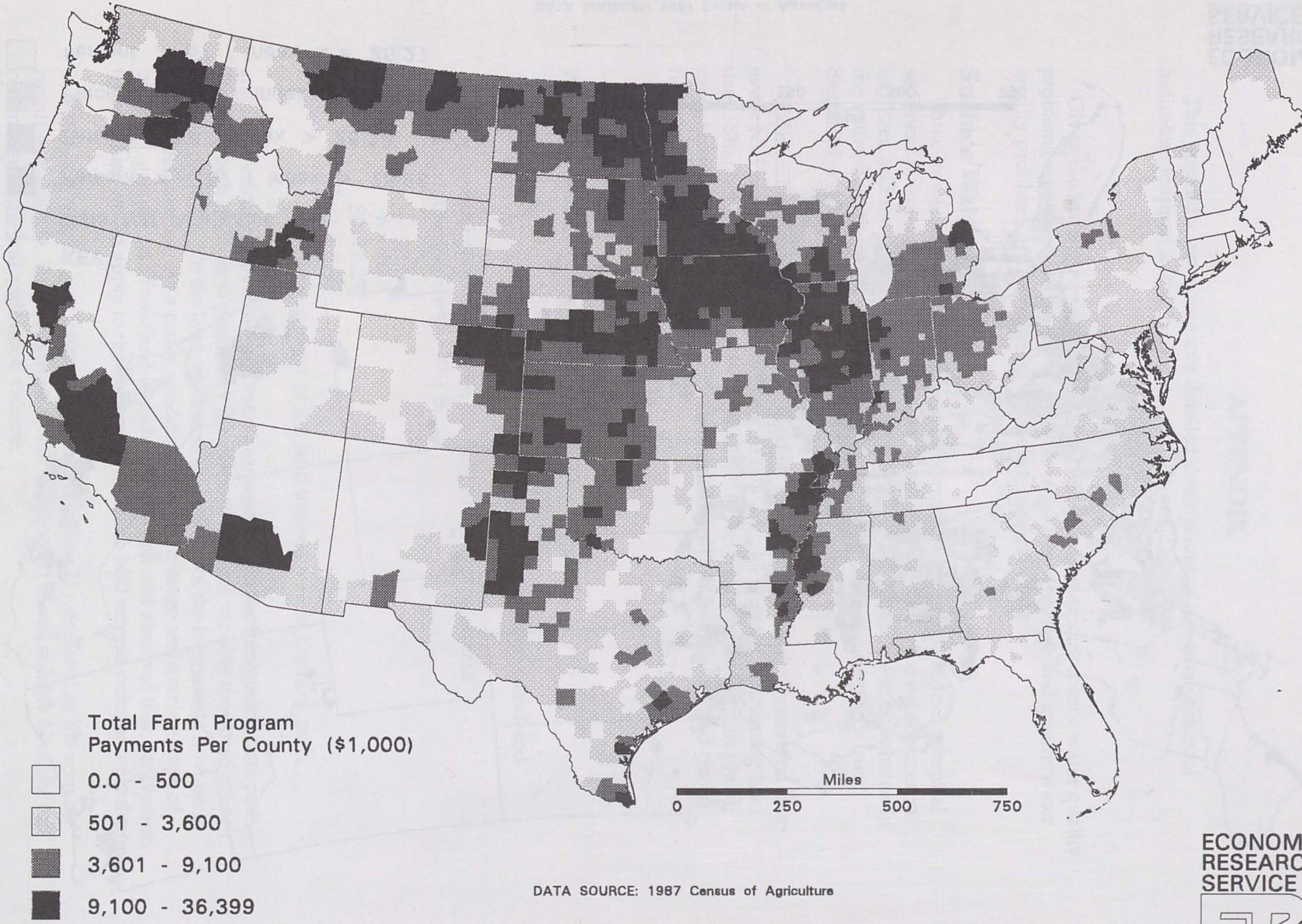

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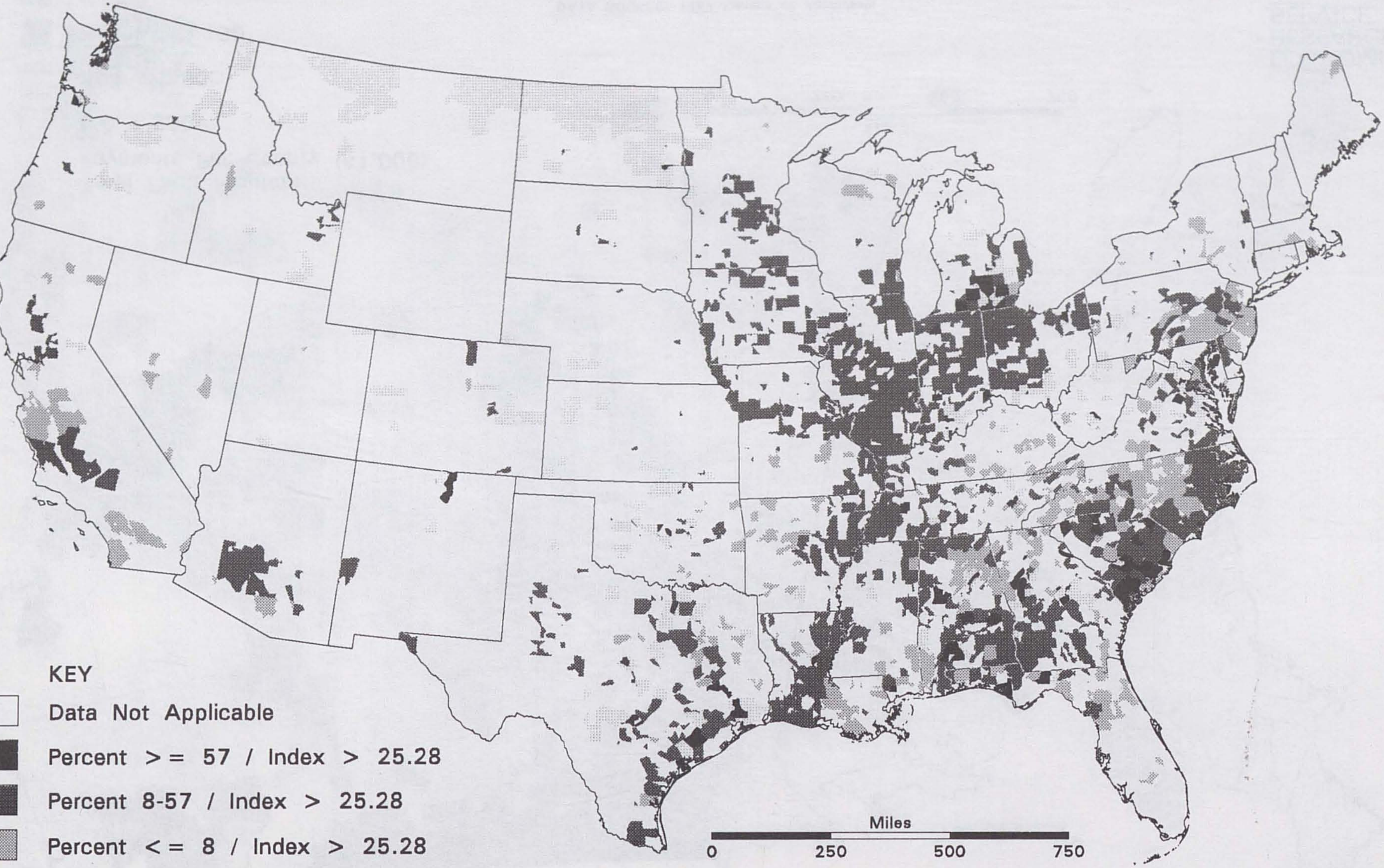
Figure 25
Percent Farm Program Payments is of Net Farm Income (per Harvested Acre) and Composite Index Score



KEY

- Data Not Applicable
- Percent >= 57 / Index > 25.28
- Percent 8-57 / Index > 25.28
- Percent <= 8 / Index > 25.28
- Percent > 57 / Index <= 25.27

DATA SOURCES: 1987 Census of Agriculture
USDA/SCS 1982 National Resources Inventory
and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

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APPENDIX

This appendix provides more detailed descriptions of the environmental indicators mapped in this paper.

Water Quality

Given the importance which the public attaches to nonpoint source water quality problems associated with agriculture, four measures of surface and groundwater quality problems are included in the environmental index.

Surface Water

Three measures of surface water quality are included in the index: potential sediment delivered to streams, potential nitrogen runoff from excess commercial fertilizer, and the potential for filter strips. All are weighted by the population in the watershed, to reflect the differential potential for reducing damages from degraded water quality.

Sediment delivery is calculated based on the distance to water, measured from every NRI sample point, and the amount and average slope of intervening land uses. Shanholtz and Kleene (1992) calculate delivered sediment by multiplying gross erosion times a delivery ratio (DR) calculated as a function of land cover, flow path length, and slope as:

$$DR = e^{-kdS_f}$$

Where k = land cover coefficient = 0.4233 for cropland
0.71 for pasture
1.1842 for non agricultural woodland

d = is the flow path length from the field to the nearest stream
S_f = slope function = $e^{-n(S + S0)} + S_{fmin}$

Where n = 16.1
S0 = 0.057
S_{fmin} = 0.60
S = slope percent of the land use segment in the flow path,

and DR is calculated over all land use/slope segments in the intervening flow path. The flow path distance is proxied by the distance to water variable measured at each NRI sample point, but the land use and slope makeup of the intervening flow path can't be determined. As a proxy, we determined the acreage and average slope of cropland, pasture, and forestland in each NRI polygon and assumed that, on average, those values would apply to the flow path from each NRI sample point in the polygon.

Following Yagow, et al. (1993, 1990), runoff N loss is calculated as the sum of runoff-extracted N. Runoff-extracted N is the product of soil soluble N in the top centimeter of the soil and runoff volume:

$$RON = .443 * CSOIL * R * 0.20 * 10^{-2}$$

$$\text{Where}\quad CSOIL = \frac{(QPORE + XNFERT * 0.05 * 73)}{.01 * (QSOIL + I)}$$

QPORE = 0.1 * CPORE * POR
CPORE = concentration of N in soil pore water = 5 mg/l
POR = soil porosity = 1-(BD/2.65)
BD = soil bulk density (from SOILS5)
QSOIL = mm of water in the top cm of soil at saturation = 10 * POR
XNFERT = excess nitrogen, kg/ha, calculated by Wen Huang for corn, wheat, and cotton crops grown at each NRI sample point.
0.05, 73 = scaling factor for annual net mineralization and annual net mineralization rate in kg/ha.

Finally, there is much support for riparian filter strips bordering streams that will intercept sediment and nutrient runoff from upland fields, before they reach surface waters. We identified NRI points representing fields within 100 feet of water bodies as having potential for filter strips.

Shortcomings and future plans—It would be nice to include sediment associated phosphorus as a surface water quality index component, but there are no available data on soil phosphorus concentrations. In addition soil phosphorus concentration can only be changed by altering fertilizer inputs over a period of several years. Retiring land in a CRP program would not appreciably affect the soil phosphorus concentration, but would reduce sediment associated phosphorus losses by reducing the amount of sediment delivered by reducing the amount of sheet and rill erosion.

Shortcomings of the nitrogen runoff map are in the nitrogen data, the populations used for weighting, and possibly the runoff calculation. Excess N calculations are for corn, wheat, and cotton only, done by Wen Huang (1992). They are based on early Cropping Practices data averaged across counties, then reaveraged across the entire state. Excess N does not include any contribution from animal manures. The watershed populations used are for the 105 Water Resources Council subareas, which are quite large. The runoff calculation produces N runoff at zero excess N because it uses the change in soil pore water nitrogen and is not particularly sensitive to large excess N loadings.

Improvements will use new excess N calculations for all crops (wheat, corn, cotton, rice, and potatoes) from 1991 and 1992 Cropping Practices Surveys, the fruit and vegetable survey data, and Area studies data, and will include a calculation of N from animal manure, where applied. I may change the way the calculation is done, as well. New watershed population estimates will be made for 8-digit hydrologic unit watershed, more closely approximating the populations directly affected over a smaller area. Low level estimates of N runoff will be censored.

Groundwater

Measures of groundwater vulnerability to pesticide and nitrate leaching are used which include both the propensity and amount of material subject to leaching and the leaching potential of the soil. Both measures are weighted by the population using groundwater sources in the county.

The groundwater vulnerability index for pesticides (GWVIP) was developed by Kellogg et al. (1992). GWVIP is a function of soil leaching potential, pesticide leaching potential, precipitation, and chemical use. It is an extension of the national level Soil-Pesticide interaction Screening Procedure (SPISP) developed by the Soil Conservation Service (Goss and Wauchope, 1990). Chemical use at each NRI sample point was inferred on the basis of the crop grown using chemical use data by crop and State assembled by Leonard Gianessi (Gianessi and Puffer, 1992, 1990). GWVIP does not depend on the amount of chemical applied, but the type of chemical, it's leaching potential, and the leaching potential of the soil to which the chemical is applied.

The groundwater vulnerability index to nitrates developed by Kellogg et al. was based on work by Williams and Goss and excess nitrogen calculations done by Wen Huang (1992) and Huang et al. (1990). Excess nitrogen per acre is the difference between the amount of nitrogen from commercial fertilizer applied, including credit for nitrogen fixed by previous leguminous crops, and amount taken up by the crop. Excess nitrogen calculations were limited to corn, wheat, and cotton crops, and did not include nitrogen contributions from applied animal manure. GWVIN is calculated in the same way as GWVIP, except that estimated excess nitrogen applied replaces the pesticide use and leaching class information used in calculating GWVIP.

Shortcomings and future plans—The GWVIP is based on Leonard Gianessi's pesticide data at the state level, allocated proportionally to the county level based on 1987 Census expenditures on ag chemicals. While GWVIP does reflect both material and soil leaching characteristics, it ignores differences in the potential harm of the chemical leached. The GWVIN is based on Wen's excess N calculations for only corn, wheat, and cotton and ignores manure.

We intend to use the new excess N calculations discussed above. We are updating pesticide application data from the CPS, F&V surveys and Area studies, averaged across state parts of MLRA's. We also intend to weight the pesticide applications by their "nastiness", the ratio of soil half-life to acute oral toxicity to mammals. This will account for differences between equally leachable pesticides that have different potential harmfulness.

Wildlife Habitat

Wildlife habitat concerns embrace both relatively common species, such as pheasant, deer, and cottontail rabbit, that adapt readily to farm environments, and rarer endemic species that are often driven to the point of extinction by agricultural development and agricultural production. To measure general changes in wildlife habitat, we use a habitat structure index developed by Carl Thomas and implemented in the 1982 NRI (USDA, 1987; Streeter, et al., 1983).

This approach describes habitat as a series of layers, each consisting of different types of vegetation and occupying a different space in the environment. Areas with more layers tend to be capable of supporting a greater diversity of species because of the larger number of available habitats. Six layers of habitat were used in constructing the Habitat Structure Index (HSI) developed for this analysis: water surface, terrestrial subsurface, understory, shrub midstory, tree bole, and tree canopy.

The layers of habitat available for wildlife depend upon the type of land cover. Six covers were considered in the analysis: fruits, nuts and other horticulture; row crops, small grains, and vegetables; grass and hayland; grass and pastureland; rangeland; and forestland. The habitat layers within each cover type vary from 3 for row crops to 5 for forestland. In addition to the number of layers present, the condition of the layers affects the habitat potential. Therefore, each layer is rated using variables describing the condition of the layer, such as tree canopy density and rangeland condition. Each layer is rated between 0 and 1 by dividing through by the maximum number of potential layers. The resulting HSI value can be interpreted as the percent of maximum potential habitat structure available. In this index, the difference in HSI between the current cropland cover and grass is calculated, measuring the potential improvement in HSI if the land were idled, or the decline in habitat structure from conversion to cropland.

In addition to habitat structure at the NRI sample point, wildlife is also affected by the diversity of uses in the surrounding landscape. Distance variables are collected in the NRI, measured in terms of feet to the nearest occurrence of water, wetlands, cropland, and other land uses. The distances are used to calculate a habitat diversity index (HDI) by summing the inverse distance-weighted presence of additional land uses. Both change in HSI and HDI components are multiplied to produce the habitat index (HI). The difference between the HI in cropped use and in CRP cover is calculated to reflect the change in habitat value that either has occurred or could occur with restoration of permanent cover in CRP.

To measure the impact on endemic wildlife species, the number of endangered species in counties with known and potential habitat was obtained from a joint Soil Conservation Service/Forest Service study (Brady and Flather; Biodata Inc.). When each of the 809 species listed as threatened or endangered were formally added to the endangered species list, counties in which the species is known to be found or that have appropriate habitat but no known populations, were added to the database. One or more of 63 reasons for species endangerment were also recorded in the database, including species threatened by agricultural development which was selected as the criteria for this indicator.

Shortcomings and future plans—The habitat structure index is intended to be evaluated in relation to a particular specie's or guild of species' habitat needs. That is, does the habitat being evaluated supply the particular breeding and feeding niches needed to support the species under consideration. However, the greater the number of habitat layers provided, the better the habitat can support a variety of species, giving a rationale for using the index as a general measure of habitat structure. The diversity component also has a drawback in that it does not measure change in diversity from changing cover at the sample point. However, an accurate measure of the amount of land changing cover relative to existing covers nearby would be needed to calculate change in HDI, and that data is not available. The threatened and endangered species index could be improved if sub-county delineations of habitat were available, but this would be a marginal improvement. There are no plans to change these two indices.

Neither of these indices is weighted by affected population because it is difficult to determine what the affected populations should be. Wildlife is enjoyed both consumptively and nonconsumptively by large numbers of people who are often willing to travel long distances. However, most hunting and nature watching is probably done relatively close to home. The problem of population weighting is even more difficult for threatened and endangered species because, for many of the more obscure species, existence values presumably make up a large part of the value set. For these reasons, there are no plans to weight the wildlife habitat indices by affected populations.

Soil Erosion

The erodibility index (EI) used by USDA for CRP and conservation compliance eligibility divides potential sheet and rill or wind erosion by the soil loss tolerance factor (T value) to reflect the vulnerability of the soil to productivity loss (Heimlich and Bills, 1986; McCormack and Heimlich, 1985). However, many soil scientists argue that currently used T values do not accurately reflect true soil vulnerability to degradation (Cook, 1983; 1982). CRP eligibility rules have also reflected disagreement as to whether potential erosion or actual erosion should be used.

As an alternative to T values, we convert the total erosion from both sheet and rill and wind, in tons per acre per year, to inches per year using the soil bulk density. This rate of soil loss in inches is divided into the topsoil depth (A horizon) from the Soil Interpretive Record (SOIL 5) associated with each NRI cropland observation. This measures how many years it would take to deplete the topsoil, at current rates of erosion. Finally, in order to reflect the relative economic value of different soils, we multiply the inverse of this measure by the productivity-adjusted dryland cash rental rate. Thus, low erosion rates or deep topsoil that will last a long time are given less weight, and more productive soils are given more weight. The resulting measure is:

$$SDI = (PE/TD)*R$$

where SDI = the soil degradation index;

TD = topsoil depth, measured as depth of the A horizon in inches;
PE = potential erosion from water or wind, described above, converted to inches/year;
R = soil-specific productivity adjusted dryland cash rent, calculated from average county rents, adjusted for differences in relative productivity of the soils occurring at 1982 NRI sample points.

A second measure reflects potential for offsite air quality damages associated with wind erosion. The amount of wind erosion at each NRI sample point is weighted by the population of the county in which the point occurs. Weighting by county population reflects the potential pool of damages from health, cleanup and maintenance expenditures associated with wind-borne dust (Piper, 1989; Huszar and Piper, 1986).

Shortcomings and future plans—A key simplifying assumption in this index arises from treating all erosion as completely removed from the field. In reality, both sheet and rill and wind erosion only move soil around on the surface of the field, with only a small fraction actually being removed from the site. Because good data are not available on differences in actual soil removal over space, the results of this assumption cannot be improved on.

County population is currently used as a proxy for potential economic damage. An improvement would be to develop population ellipses oriented in the direction of crop season prevailing wind and proportional to crop season average wind speed. Data from the EPIC weather generator are available to develop the ellipses, populated with ZIP coded population data contained within the ellipse. This would likely improve the accuracy of the map, but will not likely change the overall pattern of potential damages.

Other Environmental Problems

The two remaining environmental problems indexed are topical, relating to exposure to pesticides used in agricultural production and potential for improved floodplain management associated with cropland developed from wetlands in flood-prone areas.

Pesticide Exposure

Various indices have been developed to compare pesticide materials. Potential harm associated with agricultural chemical use is proportional to the amount of the material used, but also depends on the characteristics of materials applied. For example, all other things equal, pesticides produce greater harm the longer they take to degrade and the smaller the amount of material to achieve a given level of toxicity. Following Heimlich and Ogg (1982), we multiply pounds of each active ingredient applied by the soil half-life of each material and it's acute oral toxicity to rats.

$PEI = \sum AI*1/LD_{50}*H$ summed over all pesticides in the crop rotation or on the crop

Where:

AI = pounds of active ingredient

LD_{50}= Acute toxicity measure, lethal dose to 50 percent of lab animals. The lower this number is, the more toxic the material. We could substitute LC_{50}, which is an acute toxicity measure for aquatic organisms, or the HAL, the Health advisory level, which is a measure of chronic toxicity over an extended period.

H = half-life of the pesticide in the soil. The shorter this period, the less time the environment is exposed to the material. We could also get different half-life measures associated with foliar surfaces or in the plant, but this one is more generally available.

Shortcomings and future plans—This index is based on Gianessi's pesticide data and the suggested improvement is as above. The components of the "nastiness" index are the two most readily available, but do not reflect most of the food safety concerns: chronic toxicity (such as EPA health advisory levels), fat solubility, and bioaccumulation. Nevertheless, this is a useful start and could provoke development or assembly of better data.

Floodplain Improvement

Record flooding on the upper Mississippi and Missouri rivers during 1993 focused attention on cropland developed from former wetlands and cropland in the floodplain. This measure identifies cropland with hydric soils, indicating that it was formerly wetland, that is also located within the 100 year floodplain. This was weighted by the population in the watershed to give an indication of possible damages from flooding that could be averted by restoring these areas to wetland.

Designing Green Support: Incentive Compatibility and the Commodity Programs

by C. Ford Runge

INTRODUCTION

The purpose of this brief analysis is to consider the potential points of contact between a program of "green support" and the existing commodity programs in U.S. agriculture. These points of contact may take the form of conflict, complementarity, or neutrality. We shall assume initially that green support is "added" to the programs as they exist in 1994. Five main commodity program areas are considered:

A. Deficiency payments resulting from the loan rate/target price structure
B. Acreage reduction programs (ARPs) operating in conjunction with A
C. Conservation compliance, sodbuster and swampbuster programs
D. Conservation Reserve Program (CRP) and the Wetland Reserve Program (WRP)
E. GATT obligations and "planting flexibility" as a form of decoupling

The analysis has four main parts. First, the concept of "incentive compatibility" is explored as the basis of the analysis to follow. Second, the five main program areas noted above are considered in terms of their compatibility with a program of green support. Third is a discussion of what changes in the five program areas would make them more compatible with green support. Finally, consideration is given to how the green support program itself might be designed.

Throughout, a basic familiarity with the commodity program areas under discussion is assumed. In addition, certain general assumptions are made concerning the nature of the green support programs. It is assumed that these programs will function mainly as positive incentives, or "carrots," rather than negative incentives, or "sticks" (see Runge, 1994b). That is, they will reward farmers for behavior which either (a) mitigates existing environmental damages; or (b) improves environmental management from a current baseline. These rewards can be divided into two general categories:

- Cost-sharing, including grants, soft loans and direct "green" payments, for a variety of mitigation and/or improvement efforts, including tree-planting, terracing, and changes in crop rotations, among many other examples. These have their primary impact at the "intensive" margin.

....

C. Ford Runge is a Professor in the Department of Agricultural and Applied Economics, University of Minnesota. *Thanks to Sandra Batie, Jim Cubie, Ralph Heimlich, Sarah Lynch, John Schnittker, and Jerry Skees for comments on an earlier version.*

- Paid environmental set-asides such as the U.S. Conservation Reserve Program (CRP) and Wetlands Reserve Program (WRP), either expanded or altered from the current basis. These have their primary impact at the "extensive" margin.

When examined in this light, it is clear that programs already exist which fall into the general category of green support. However, a variety of "sticks," notably penalties for non-compliance with conservation requirements, remain critical to this analysis, since it establishes a threshold beyond which environmental damages will not be tolerated. We now consider the potential role of green support programs at an expanded level, in relation to existing programs.

What is Incentive Compatibility?

If green support is added to the existing mix of farm programs, "this layering of existing and green programs could result in an incentive structure which either is mutually reinforcing, is at cross-purposes or is non-overlapping" (Lynch, 1994). A formal approach to this mix, generally attributed in large part to Hurwicz (1972), is known as "incentive compatibility." In this paper, we shall adopt a simplified version of this approach originally described by Schelling (1960), in which incentive compatibility is positive, negative, mixed, or neutral[1].

In describing these distinctions, Schelling used the example of Sherlock Holmes and his opposite Moriarity, in which Holmes and Moriarity were traveling aboard separate trains, let us say between Oxford and London. Four combinations of incentives are possible. In one, Holmes and Moriarity each benefit most if they get off at the same station. This is a positive sum situation in which their incentives are to coordinate their behavior. The second situation is one in which they each benefit most if they get off at different stations. This is a negative sum situation in which their incentives conflict. Third are situations in which both Holmes and Moriarity seek to get off at the same station, but the station Holmes prefers is different from that which is most preferred by Moriarity (e.g., Reading versus Basingstoke). This is described as a game of "mixed motives," in which their incentives are partially but not entirely aligned. For completeness, it should be noted that a fourth situation may exist in which either Holmes or Moriarity, or both, are entirely indifferent respecting the opposite's action.

Let "Holmes" stand for the commodity programs and "Moriarity" for green support. The first case corresponds to the notion that certain commodity and green support programs would motivate farmers in ways that are mutually reinforcing. The second is one of incentives that are wholly at cross-purposes. The third situation is also partially one of cross-purposes, but in which gains are still possible from some coordination. The fourth case is one of non-overlapping, or neutral, incentives. In the discussion to follow, we shall adopt these distinctions, together with a conventional nomenclature for positive, negative, mixed and neutral effects, as shown in Figure 1. These effects indicate the direction of incentives for environmental improvement from the commodity programs as they affect programs of green support.

Figure 1. (Commodity Programs, Green Support Programs)

1. Pure Positive Incentives	(+, +)
2. Pure Negative Incentives	(-, -)
3. Mixed Incentives	(+, -) (-, +)
4. Neutral Incentives	(+, 0) (- , 0) (0, -) (0, +) (0, 0)

As Figure 1 shows, these four situations generate two "pure" forms of coordination and conflict. The third case, of mixed incentives, can be positive for commodity programs, while negative for green support, or vice versa. The fourth case generates five possibilities: positive/neutral, negative/neutral, neutral/negative, neutral/positive, and neutral/neutral. In all, nine possible relationships exist.

A last preliminary comment concerns the direction of causality or effect. In general, because of their size and influence, we assume that the commodity programs dominate green support. However, it is possible that in time green support will actually drive the decision of farmers to participate in the programs we shall review below.

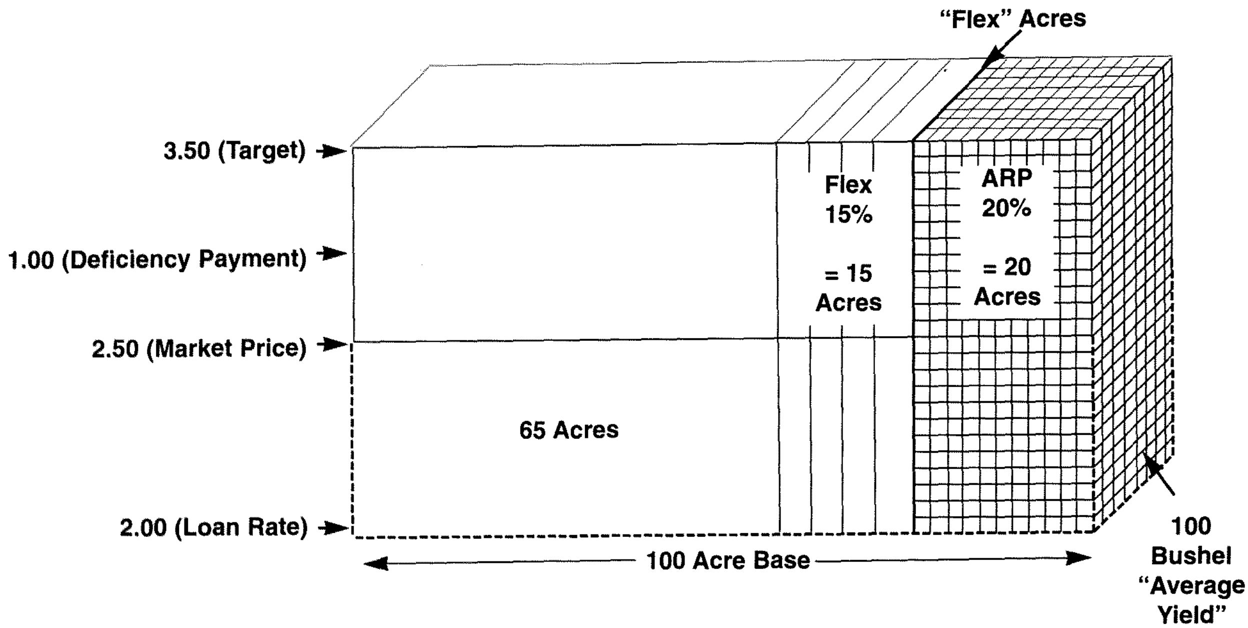
Commodity Programs/Green Support

Deficiency Payments: Loan Rates and Target Prices

The loan rate and target price, together with market prices, jointly determine the limits of the deficiency payment paid to farmers who elect to participate in the price support programs offered for many field crops, notably corn, wheat, oats, barley, cotton, and rice (for a discussion see Cochrane and Runge, 1992, Chapter 3). This scheme of price support truncates the distribution describing possible price fluctuations for crops, assuring farmers of the market price or loan rate (whichever is higher), plus a deficiency payment equal to the difference between the market price (or loan rate) and the target price, multiplied times an average yield-per-acre figure and the number of "base" acres for a given crop on a given farm. In return for this price protection and risk reduction, farmers are required in certain years (depending on USDA determination in a given year) to set aside, through the acreage reduction program (ARP) and occasionally through paid-diversions, a proportion of this "base." In 1990, an additional "flex-acres" requirement of 15 percent of base was added, on which no deficiency payments are made (see Figure 2)[2].

The primary consequence of this arrangement is to encourage farmers to grow the program crops so supported, and thus to build and retain "base." In the 1980s, as much as 95 percent of program crop acreage was enrolled in the federal commodity programs (National Research Council, 1989). Complying base acreage as a percent of program crops ranged from 43.6 percent in 1982 to 106.4 percent in 1987. These percentages have fallen slightly in the 1990s, in part because the yields on which deficiency payments are

Figure 2. How Deficiency Payment are Calculated (with Acreage Reductions).



Source: Adapted from Cochrane and Runge, 1992, p. 70.

calculated have been frozen, and in part because of the "flex-acres" mandated for program participants. But risk reduction continues to make these programs attractive, and thus encourages farmers to forego other crops or to alter rotations, in order to secure this protection.

The environmental impacts of these programs are not the main focus of this analysis; it is the incentive compatibility between them and green supports. However, numerous empirical studies strongly suggest that high deficiency payments distort incentives in ways which run counter to the rewards contemplated under green supports, encouraging monocultures, reducing planting flexibility, and increasing intensity to boost yields (Young and Painter, 1990; Dobbs, et al., 1988; Lyman, et al., 1989). For example, Just, et al. (1991), simulated the impacts of deficiency payments for wheat and corn on irrigation and groundwater depletion in the Ogallala Aquifer. The study also estimated impacts of acreage diversions. It concluded:

> We show that increases in target prices and price supports produce sizeable increases in the adoption of irrigation and therefore groundwater depletion. Interestingly, high price supports coupled with more stringent diversion requirements increase irrigation and groundwater depletion substantially in as short a time as 5 years. This finding bears out quantitatively previous conjectures that efforts at supply control give farmers a strong incentive to increase yields by intensifying cultivation (p. 231).

Now imagine that green supports — such as cost-sharing, direct payments, or paid set-asides — were available at attractive enough levels to encourage farmers to engage in agronomically more sound rotations, or to reduce production intensity by limiting irrigated acreage. How do such green supports interact with the deficiency payment? In effect, the deficiency payment raises the ante required in order for green supports to represent an attractive alternative. While farmers might well desire to engage in such environmentally sound practices with green support, they still would benefit more from retaining base and restricting rotations by seeking the shelter of the commodity programs.

The situation is thus one of mixed motives, in which farmers are attracted to alternatives with green support, but in which traditional deficiency payments, and the commitment to certain cropping patterns they engender, remain even more attractive. If green supports were "layered" on top of deficiency payments (as they are, in effect, now), deficiency payments raise the amount of green support necessary to induce a change in behavior. The incentive compatibility relationship, as shown in Figure 3 is one of mixed motives (+, -).

Figure 3. Green Support Programs and Incentive Compatibility

EXISTING PROGRAMS	GREEN SUPPORT Incentive Compatibility
A. Deficiency Payments	(+, -)
B. Acreage Reduction Programs (ARPs)	(+, +) (if targeted to high pollution-to-output land)
	(+, -) (if targeted to low pollution-to-output land)
	(+, 0) (if untargeted)
C. Conservation Compliance, Sodbuster and Swampbuster Programs	
As currently structured	(+, -) (due to A. above)
If penalties decoupled from A. and B.	(+, +)
D. Conservation Reserve Program (CRP) and Wetlands Reserve Program	
As currently structured	(+, -) or (+, 0) (due to supply control target [same as B.])
If retargeted to high pollution-to-output land	(+, +) (same as B.)
E. GATT Obligations and Planting Flexibility as a form of "Decoupling"	(+, +)

Acreage Reduction Programs (ARPs)

The next program area involves the set-asides required on a year-to-year basis in return for participation in the commodity programs. These acreage reductions are designed to reduce the amount of budget exposure for federal commodity program outlays and to reduce surpluses.

Because the amount of acreage reduction is determined by the U.S. Department of Agriculture (USDA) annually prior to planting, it is difficult to guess how much the supply control "brake" should be applied in the face of the "accelerator" of both market and government price signals. Moreover, farmers regularly retire acres of lowest productivity, leading to substantial "slippage" in the amount of production actually reduced through mandated acreage reduction. Over time, income support programs also have increased the amount of investment in added capacity, contributing to growing problems of surpluses. Roberts, et al. (1989) concluded that the "brakes" approximately offset the "accelerator," so that "the production reducing effects of the acreage reduction arrangements approximately offset the short term production stimulating effects of the deficiency payments."

In effect, the ARPs shift production from the extensive to the intensive margin. As Antle and Just (1991) show at a theoretical level, the environmental impact of such production control depends on whether the land taken out of production has a higher or lower pollution-to-output ratio than the land remaining in production. Since it is rational for farmers to divert lower productivity acres, the question is the joint distribution of productivity and vulnerability to erosion or other pollution-creating characteristics (see Heimlich, 1989; Taff and Runge, 1988; Rausser, et al., 1984).

In general, however, ARPs are difficult to target to high pollution-to-output acres compared with longer term set-asides. Osborn (1993) and Heimlich and Osborn (1993) show that in practice, ARPs have failed to establish adequate vegetative cover and are constantly shifted from one location to another, failing to provide any consistent impact on erosion control.

If ARPs (or other diversions, such as the Conservation and Wetlands Reserve Programs considered below) are targeted to land highly vulnerable to erosion or with other high pollution-to-output ratios, then they will be more consistent with green supports also designated to reduce such pollution events (+, +). Unfortunately, ARPs and other diversions have been oriented in substantial part toward production control, implying a preference for higher output lands and thus lower pollution-to-output ratios. The result is to raise the intensity of production on lands remaining in crops and to aggravate pollution events, operating partially at cross-purposes (+, -). Since ARPs are also shifted from one location to another, and vary in extent from year to year, and are thus untargeted to environmental goals at present, they are at best random in their pollution-to-output effects. The result would presumably be neutral with respect to green support (+, 0).

Conservation Compliance, Sodbuster and Swampbuster Programs

Three main conservation programs were implemented as part of the 1985 farm bill and reauthorized in 1990, which make receipt of federal agricultural subsidies conditional on adherence to certain environmental management practices. These three programs are known as conservation compliance, swampbuster and sodbuster requirements, and represent the main "sticks" or negative incentives used to induce environmentally responsible farm-level behavior.

When originally devised in the 1985 farm bill, these penalties were set in terms of the loss of all future farm program payments, as well as eligibility for federal crop insurance and other USDA benefits. In 1990, this so-called "drop dead" penalty was adjusted so that local ASCS committees could impose penalties graduated from $500 to $5,000, depending on the severity of the violation. While this adjustment has helped to reduce the apparent lack of proportionality between the penalties and the offenses involved, there are still serious difficulties with these programs.

Conservation compliance requires farmers with fields classified as highly erodible to develop conservation plans for their farms, and by 1995 requires full implementation of these plans. Farmers who fail to implement them potentially face the financial penalties described. Conservation compliance has faced several problems related to general agricultural subsidies to which it is held hostage, that make it difficult to implement (Gardner, 1993, pp. 16-17). In this respect, its incentive effects emerge directly from the loan rate/target price mechanism described above.

First, high reliance on government deficiency payments (and other government payments) for net farm income has continued to make farmers and their elected representatives in Congress view even the adjusted penalties for noncompliance as excessive. Enforcement has been problematic, and a variety of loopholes have been created through legislative and administrative means so that local committees primarily responsible for enforcement have penalized relatively few.

The 1990 farm bill language establishing the graduated sanctions provided additional discretion for USDA to waive ineligibility for program benefits if the farmer is found to have "acted in good faith and without the intent to violate the provisions of this subtitle," and/or if the violation is "technical and minor in nature." How "intent" is to be shown in such cases is problematical, as are local interpretations of "technical and minor."

Second, in any case, with higher market prices (and lower deficiency payments), the incentive to undercut conservation compliance remains, because when prices are high, conservation is most threatened by the incentive to farm every available acre. And when market prices are high, the penalties for noncompliance appear relatively low. As the Economic Research Service (ERS) of USDA noted in a 1990 report:

> The effectiveness of the conservation provisions depends upon the attractiveness of Federal price and income support programs. If Federal

commodity support programs become less attractive due to such factors as higher market prices or increased set-aside requirements, the conservation provisions will become less effective (Young and Osborn, 1990, p. 31).

Third, conservation groups have also charged that Soil Conservation Service (SCS) offices have retreated from conservation compliance under pressure from farmers who claim that its requirements are too strict and its penalties too severe. Federal authorities responsible for administering conservation compliance changed the erosion goal from soil loss tolerance levels (T-values) required in the basic conservation system (BCS) to alternative conservation systems (ACS) which required a "substantial level of erosion control at reasonable cost." These levels were interpreted very differently from state to state as field office technical guides (FOTG) were developed, and make comparative evaluations of conservation compliance very difficult (Heimlich, 1994a). Noting weakened standards in the key farm states of Iowa and Nebraska in April, 1990, the Center for Rural Affairs (1990) raised the concern that "The SCS is sending a signal to other regions and states that weaker erosion standards are acceptable."

The "sodbuster" and "swampbuster" provisions suffered from related problems. "Sodbuster" is designed to limit the plowing of cropland designated as highly erosive, and "swampbuster" to limit the conversion of designated wetlands to croplands. To do either leads, as in conservation noncompliance, to the penalties described. Again, these laws are likely to be undercut precisely when they are most needed if administrators and legislators view the penalties involved as excessive. Like conservation plans, sodbuster and swampbuster conditions are interpreted and enforced by local committees acting on behalf of the USDA. At the local level, where the offending farmer is likely to be well-known to committee members, administering the penalties is especially difficult. To date, only a relatively few such penalties have been handed down, and many have been overturned on appeal. Cook and Art (1993) report that as of 1992, 1,953 producers were found in violation of conservation compliance, sodbuster, and swampbuster requirements, leading to denial of $10.8 million. However, $4.6 million was restored on appeal, leaving a net of $6.2 million in penalties. This is roughly equal to less than one-half of one-percent of total commodity program payments in the single year 1992. The real issue is whether the USDA can and will actively enforce these laws after 1995, when conservation plans are to be fully implemented.

Estimating the impact of green support layered on top of conservation compliance, sodbuster and swampbuster is thus complicated by the fact that they are all a function of the deficiency payments and other programs, including CCC loans, FmHA loans, crop insurance, etc., the denial of which potentially constitutes the penalty for noncompliance. Hence, reducing or eliminating the loan rate\target price mechanism or other USDA program benefits would convert the penalty from what is currently a highly unlikely event to one with zero consequences.

However, there is no reason in principle why the penalties for noncompliance should be tied to USDA programs, and there are several reasons already described why they should not. Many farmers do not participate in these programs, and fewer are likely to in the future if program benefits fall before budget cuts. If all penalties for noncompliance were assessed directly by an agency outside of the USDA, utilizing the graduated structure currently on the books, like traffic tickets, even clearer signals would be sent to farmers. These penalties would be considerably easier to administer and enforce if responsibility for them were removed from local committees of the USDA. Once these noncompliance penalties were decoupled from the commodity and other USDA programs, green support could operate as a complementary "carrot" to the "stick" they would represent, both driving in the same direction (+, +).

Conservation Reserve Program (CRP) and Wetland Reserve Programs (WRP)

In the face of major crop surpluses in the early 1980s and as a result of new demands from environmental groups, the CRP became part of the Food Security Act of 1985, and was reauthorized in the 1990 farm bill. The 1990 farm bill also authorized a Wetland Reserve Program (WRP), which pays farmers to restore wetlands by offering easements. The WRP and CRP, as well as the Water Quality Improvement Program (WQIP), together constitute the Environmental Conservation Acreage Reserve Program (ECARP). To date, the WRP has been capped for budgetary reasons at 50,000 acres in 1993, which was raised in fiscal year 1994 to 75,000 acres (Gardner, 1993, p. 18). This compares with 36.5 million acres currently enrolled in the CRP. Together the CRP and WRP constitute the most major effort to date to undertake "green support." They are thus worthy of especially detailed analysis of incentive effects.

The CRP, like its 1956-62 precursor the Soil Bank, pays volunteering farmers to retire land from field crop production and to plant grasses and/or trees. CRP contracts are 10 years. The original Soil Bank paid farmers to retire cropland for 3- 10 years (10-15 years for trees). In return farmers received an annual rental payment and 80 percent cost-sharing to plant cover crops or trees. No limits were placed on individual acreage enrollment and "whole farm" retirement was rewarded with a 10 percent rental bonus. Where trees were planted (2.1 million acres) especially in the South of the U.S., nearly 90 percent remained planted to trees in 1976 (Alig, 1980). However, much of the rest of the Soil Bank, especially in the Midwest, was returned to field crops in the 1970s and 1980s.

As CRP contracts begin to expire in 1996, a question arises: will the CRP, like the Soil Bank, simply end up as a temporary measure to remove land from production? Or can the incentive to protect vulnerable lands be retained through a revised program of green support? The answer to these questions requires disentangling the two primary objectives of the CRP: surplus crop reduction and environmental protection. These two objectives have confounded the incentives of the program from the outset, and have different implications for a layering-over of green support payments.

From the outset, the CRP has attempted to do two things at once: reduce surpluses and protect highly erodible lands. Like conservation compliance, sodbuster and swampbuster provisions, the CRP has been affected by motivations tied less to conservation than to the farm subsidy programs. It was thus in large part justified as an addition to the Acreage Reduction Program in controlling crop surpluses. This has created serious incentive problems.

First, the opportunity cost of the 10-year contract is set by the market price of the commodities which <u>could</u> be grown on CRP acres, and thus is related to deficiency payments, which fall with rising market prices. When market prices were weak and deficiency payments high (as in the 1985-86 period when the CRP began), the program looked relatively "cheap" to the USDA relative to direct paid land diversions. However, in order to attract farmers into the program, rental payments had to be competitive with target prices on base acres. As a result, the USDA had to pay rental rates well-above market rents in most areas of the country in order to induce enrollment (in some cases 200-300 percent higher) and even offered bonuses for corn base acres.

These bonuses reflected a second major problem: because the CRP was understood as a mechanism for supply control, the lands targeted for retirement gave explicit priority to reducing cropland acres, rather than to the most environmentally vulnerable lands, which might include pasture, forestland or wetlands with no cropping history. Specifically, farm base acreage (defining eligibility for crop subsidies) was reduced when land was enrolled in the CRP according to the ratio between acreage put in the CRP and total acreage for "program crops" on the farm. For example, if a farmer had a 200-acre farm (all of which were "crop acres") and a 100-acre corn base, and put 50 acres into the CRP, the ratio of CRP acreage to total cropland was 50/200, or 1:4, and corn base was reduced by 25 percent, or from 100 to 75 (Cochrane and Runge, 1993, Chapter 3).

The result of this "base bite" was to further increase the reservation rent which the government was required to pay to induce farmers into the program. The CRP will cost about 19.2 billion dollars between fiscal years 1987 and 2003. A 1989 GAO report found that it could have been much less costly and more effective, and that the USDA was focusing mainly on getting acres into the CRP, rather than on fulfilling its environmental objectives (GAO, 1989). Despite some broadening of program design, a 1993 GAO report concluded:

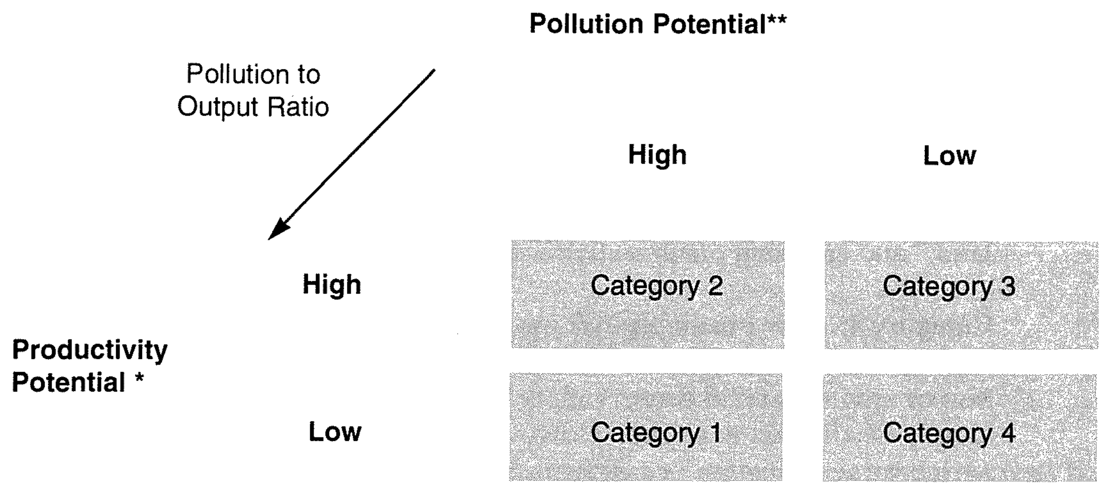
> CRP is an expensive way to reduce the environmental problems linked to agricultural production. The program will require budget outlays of about $19 billion to take 36.5 million acres out of production; however, not much is known about the dollar value of the environmental benefits purchased or about the extent to which removing the land from production will alleviate environmental problems associated with agriculture (GAO, 1993, p. 8).

Finally, as surpluses have dwindled and market prices have risen, both farmers and the government find the CRP less attractive as a supply control measure, and the desire to be done with it grows. Its impact on total acres in production is significant. Yet simply eliminating it would do nothing more than repeat the Soil Bank experience, at considerable cost. Current policy discussions in the U.S. are focused on three key issues:

- Which lands now under CRP contract should be returned to active cropping (although still subject to the 1995 conservation plans under "conservation compliance")?
- Which lands now under CRP contract should remain under restrictive contract, and what form should this contract take?
- Which lands not now under CRP contract should come under some form of additional environmental restrictions?

In order to answer these questions, a targeting distinction needs to be made between land that is "marginal" from a supply control perspective (because it is unproductive and has low output) and land that is "marginal" from an environmental perspective (because it is vulnerable to erosion damage or otherwise manifests high pollution potential). In Figure 4, these two dimensions, identified as "productivity potential" and "pollution potential" are described as continuous variables, but are divided into "high" and "low" categories for purposes of discussion. The approach shown in Figure 4 has been applied in a practical setting by the State of Minnesota, in implementing a state-level set-aside discussed below (Larson, et al., 1988).

Figure 4. Pollution and Productivity Potential



*Measurable either as yields per acre on the basis of historical data or in terms of productivity indices calculated for various soils.

**Pollution potential can be expressed in terms of erosion potential, or more broadly to reflect land parcels subject to groundwater contamination, strips along protected streams, wetlands, or areas of special value as wildlife habitat, etc.

It is apparent that land in Category 1 has a high pollution-to-output ratio, while land in Category 3 has a low pollution-to-output ratio, and that land in Category 2 has high pollution and high output, making the ratio uncertain but clearly intermediate to Categories 1 and 3.

Category 1: Low productivity/High vulnerability land

Land in this category has limited potential for supply control, but is highly vulnerable to pollution. It is thus land which, if currently enrolled, should remain in the CRP or under some form of restrictive easement, preferably on a permanent basis. Land not currently in the CRP, but falling in this category, should also be targeted for permanent retirement from cropping through land-use restrictions, including conservation compliance, sodbuster or swampbuster. Because its productivity is low, the opportunity cost of its removal from cropping is also low. Hence payments to farmers to retire it or not to crop it should also be relatively low.

Category 2: High productivity/High vulnerability land

Land in this category has high productivity potential, but is also highly vulnerable to environmental damages from pollution. If it is currently in the CRP, it should remain so, protected by a restrictive easement which will require a higher price paid to participating landowners than Category 1 lands. There may be reason not to seek permanent easements, simply because on a short-term basis, its productivity might be needed. If it is not currently in the CRP, then efforts should be made to designate it through conservation compliance criteria, restricting cropping in most cases. Some additional CRP contracts might be offered where needed.

Category 3: High productivity/Low vulnerability land

Some land in the CRP already falls in this category. In these cases, current CRP contracts should be allowed to expire, and only limited land-use restrictions should be imposed in the future, consistent with conservation compliance requirements. Land in this category not currently in the CRP should be granted special status as "sustainable cropland," and cropping practices that maintain its high productivity should be encouraged.

Category 4: Low productivity/Low vulnerability land

Lands in this category are of relatively limited value for either agricultural production or environmental conservation. If they are now in the CRP, such contracts should simply be allowed to expire. However, this land may be especially well-suited for non-agricultural, industrial or residential uses, and land-use restrictions, zoning ordinances, and land-use planning could all reflect these considerations.

Implementing CRP Targeting Criteria

Categorizing land into such divisions is not especially demanding from an analytical or official point of view. The approach is adaptable to local conditions, so that relative rather than absolute standards could be set for given geographic areas, while maintaining federal oversight. Such divisions could go a long way toward tailoring policies which would:

- maximize the environmental benefits of land use restrictions, even where these benefits are difficult to quantify;
- reduce budget expenditures for land retirement contracts or easements; and
- release highly productive and relatively non-vulnerable cropland from the CRP.

Apart from the CRP, these categories could also be used to calibrate penalties for non-compliance with conservation requirements. If these penalties were divorced from the commodity and other USDA programs, and paid like traffic tickets, enforced outside of the USDA, penalties would be highest on Category 2 lands, followed by Categories 1, 3 and 4.

Suppose now that funds are available for green support to continue some form of modified CRP. This discussion offers some targeting guidelines for green support, which follow along the same lines as the earlier discussion of ARPs (see Figure 3).

- Land which is highly productive but not vulnerable to environmental pollution (low pollution-to-output ratios) should be allowed to produce on a sustainable basis largely free of restrictions on cropping practices.
- Land which is highly vulnerable to environmental pollution, whether productive or not, should be subject to strict conservation standards, compliance requirements and should be retired on a permanent basis if low in productivity, and on a time-limited contract if higher in productivity.
- Penalties for violations of conservation requirements should be adjusted to be proportional to damages, and enforced by an agency other than the USDA.
- Payments for land retirement on either a permanent or time-limited basis should reflect the productivity of the land, with lower payments for lower productivity lands[3].

In sum, as currently structured, the CRP operates very much like the supply control mechanism of the ARP, and fails to maximize environmental benefits. By encouraging intensive cultivation of non-CRP acres, and focusing excessively on supply control, it has failed to target high pollution-to-output lands. Such retargeting would shift much of the CRP from the (+, -) or (+, 0) to the (+, +) incentive category.

GATT Obligations and Planting Flexibility as a Form of "Decoupling"

The 1990 farm bill mandated that 15 percent of "base" acres for the program crops be treated as flexible acres, on which farmers were free to plant other crops (subject to certain restrictions) in return for which they would forego deficiency payments. These "flex acres" were a remnant of a larger 1990 proposal to make the entire base flexible, also known as Normal Crop Acreage (NCA). The 15 percent "flex acres" in the 1990 farm bill represented an incremental step toward "decoupling" commodity price supports from specific crop bases. The NCA concept would move even more dramatically toward such decoupling. In the context of the now-completed GATT (General Agreement on Tariffs and Trade) negotiations, decoupled approaches have been given additional impetus, since it is generally acknowledged that decoupled supports are less trade distorting.

Various empirical analysis have supported the idea that greater planting flexibility would reduce the force of the "vise grip" described earlier in connection with the commodity programs. Young and Painter (1990), in their case study of the Palouse Region, found that if an NCA had been in place in 1986-90, rather than the 1985 farm bill provisions, "the NCA would have been markedly more effective in sheltering the base of a farmer using the environmentally sustainable perpetrating alternative legume system (PALS) rotation" (p. 13). In a 1991 world Resources Institute study, based on micro-level analysis of representative farms, Faeth, et al., argued that decoupling farm subsidy payments would provide greater environmental benefits than a variety of alternative policies. The authors concluded:

> Multilateral decoupling provides the greatest net economic value of the policies we tested. The simple fact that income support is not tied to commodity production allows market signals to reach farmers, encouraging

> them to use their resources in ways that are inherently more efficient. In areas with high resource costs, farmers who take a long view would likely shift to resource-conserving rotations, while in regions with low resource costs, farmers would shift to less chemical- intensive methods (p. 20).

More recently, Feinerman, et al. (1993) at the Center for Agricultural and Rural Development (CARD) simulated the effect of planting flexibility in the face of tightening environmental regulations, specifically a ban and a tax on the use of corn root worm herbicide. They concluded that such "Base flexibility relaxes a constraint for producer behavior... [and] can be tied to a ban or a partial ban on corn rootworm insecticides as a way of compensating farmers for associated income loss" (p. 14). Referring specifically to the incentive effects of planting flexibility and environmental improvements, they noted that "flexibility in commodity policy is important to the maintenance of farm income for producers that must comply with restrictive environmental policies" (p. 2). Moreover, because of the interdependencies between commodity and environmental policies, greater planting flexibility offers "opportunities for win-win or near win-win outcomes from more coordinated policy actions" (p. 3).

If green support were added to this mix, it thus would be highly complementary to planting flexibility, and could even be used as a primary mechanism to substitute decoupled green support for deficiency payments tied to base (+, +).

Changes in Existing Programs to Increase Compatibility with Green Support

The analysis above leads to three clear implications concerning existing programs. Each of the changes identified below would increase compatibility with green support.

- Deficiency payments should continue to be eliminated in favor of flexible acres. In place of these payments direct decoupled support should substitute for commodity-specific price guarantees; however, these payments can be "greened" by recoupling them to various environmental objectives.

- Acreage Reduction Programs (ARPs), as well as the CRP and WRP, can all be made more compatible with green support by targeting them to high pollution-to-output ratio lands. ARPs would continue to apply to crop acreage bases, but CRP and WRP would be broader in scope.

- Conservation Compliance, Sodbuster and Swampbuster requirements should be decoupled from the commodity programs and applied to all farmland, including pasture and lands without cropping histories whether it is in or out of the farm programs. Graduated penalties for non-compliance would then be applied based on the severity of the problem and the size of the land parcel involved by an agency outside the USDA, using the same criteria applied to target the ARP, CRP and WRP.

Each of these proposed changes arises directly from the lack of incentive compatibility discussed above. However, it is most useful to think of these changes as a package, and to envision how current programs might begin to shift in the direction of green compatibility over time, utilizing the billion dollars or more currently devoted to conservation in more effective ways.

The 1990 farm bill provisions for 15 percent flexibility represented a step in the direction of decoupling, which has been documented to improve the capacity of farmers to respond to environmental regulation (Feinerman, et al., 1993), and to alter rotation practices in a resource-conserving way (Young and Painter, 1990; Faeth, et al., 1991). However, continuing to increase the proportion of "flex-acres" in relation to total base also reduces the income security represented by deficiency payments. It is, therefore, unlikely that additions to flex-acres to, say, 30-50 percent from the current level of 15 percent, would be feasible without some form of additional revenue or income assurance. However, a fixed payment per acre could be offered in lieu of deficiency payments, essentially along the lines of the 0-92 provisions of the 1990 farm bill. This payment could be constant, but preferably would fluctuate inversely with farmers' terms of trade (prices received versus prices paid) (see Cochrane and Runge, 1992).

As will be described in detail below, these payments could be "greened" by graduating them to reflect advanced soil-conservation methods such as no-till, the use of alternative crop rotations, extensive livestock/cropping, integrated pest management, wetlands rehabilitation, diversified forest plantings, and a wide range of other approved practices reflecting local priorities for sustainable agricultural development. A specific scenario for this type of green support is illustrated in Appendix 1.

Increases in planting flexibility to levels of 30-50 percent (or even to 100 percent, as under Normal Crop Acreage) do not imply that the U.S. Department of Agriculture would need to abandon the Acreage Reduction Program (ARP) as an instrument of policy. ARPs in the form of some planting restrictions could continue to apply either to the complement of base <u>not</u> in flex-acres (e.g., 20 percent ARP on 50 percent of corn base not treated as flex-acres, equal to 10 percent), or even to Normal Crop Acres (e.g., no more than 90 percent of NCAs to be planted to corn). Whether ARPs would be any more effective under these circumstances than currently in restraining production is an important question, but is outside the scope of this study.

What is most germane to the issue of green support, however, is that acreage set-asides with environmental aims, especially a revised CRP and WRP, respond primarily to environmental objectives rather than serving as programs of supply control. The simplest way to assure that they do is to continue the trend toward explicitly targeting high pollution-to-output acres, and graduating payments for conservation set-asides such as the CRP and WRP to reflect the opportunity cost in productivity of removing these environmentally vulnerable lands from production and engaging in approved conservation management practices. Such payments would then become an additional green support option for landowners, whether they were participating in the flex-acres/deficiency payment scheme or not.

Finally, conservation compliance, sodbuster and swampbuster would continue to apply to all farmland, independent of participation in the above programs. The result would be to pose a choice to the landowner: be liable for these requirements without compensation in the form of green support, or get on board (for example, by signing up for a CRP or WRP contract) and engage in management practices which receive green support as well. In effect, the requirements of conservation compliance, sodbuster and swampbuster would establish a baseline, or threshold, below which penalties would apply, graduated to reflect the severity of the infraction. Management practices above this threshold, representing "affirmative action," would become eligible for green support.

Designing Green Support Programs

The three elements of the policy reform package described in the previous section also provide the basis for designing a green support program. The program would be composed of three parts, two "carrots" and one set of "sticks."

- Increased participation (whether voluntary or mandatory) in flex-acres would be compensated with decoupled payments; these payments could be "greened" by graduating them to reflect a wide array of locally-developed sustainable practices, with local and federal priorities determining the level of green compensation.

- Acreage set-asides (ARPs, CRP, WRP) would be targeted to high pollution-to-output acres, with compensation (in the case of CRP and WRP) graduated to reflect productivity differences. Such payments would constitute the second main form of green support, and could also be varied depending on landowner willingness to engage in locally and federally approved conservation management alternatives.

- Conservation Compliance, Sodbuster and Swampbuster requirements would be expanded to include all federally designated lands, whether or not enrolled in federal farm programs. Penalties for violations would be graduated to reflect the severity of the infraction and the acreage involved, and would be entirely divorced from the commodity programs. These requirements would set minimum acceptable management practices.

As in the reform of existing programs, the design of green support should be thought of as a package. The expansion of flex-acres, independently of green payments, should increase the ability of farmers to respond to environmental objectives. By substituting decoupled support for deficiency payments, and graduating and "greening" this support to reflect local and federal conservation priorities, trade-distorting subsidies are eliminated at the same time that environmental needs are targeted. Decoupling is thus accompanied by "recoupling" to environmental objectives. Conservation acreage set-asides would be the second main option for landowners. Finally, stringent and more widely applied requirements for conservation compliance, sodbuster and swampbuster would create a stick for noncompliance.

Appendix 1: An Example

Consider a 400 acre corn-soybean farm in the Mississippi Valley with 300 acres of corn base and 100 acres enrolled in the Conservation Reserve Program, with a CRP contract terminating in 1997. Under the proposed reforms, mandatory "flex-acres" under the 1990 farm bill equaling 45 (300 X .15) might be expanded to 90 (300 X .30), to a total of 30 percent. In addition "optional flex-acres" could be offered, with decoupled compensation, up to 50 percent of total base. If the farmer had been receiving a deficiency payment of $1.00 per acre and had yields frozen at 100 bushels, then his loss in revenue from the mandatory expanded flex-acres would be

($100.00 X 45 = $4,500).

This income foregone due to increased flexibility would be combined with the prospect of loss of CRP revenues beginning in 1997-98. Suppose that a per-acre payment of $75 under the CRP, equal to $7,500 a year, would be lost. Then the losses of flex-acre expansion from 15 to 30 percent ($4,500) combined with the annual CRP loss ($7,500), would represent a $11,500 reduction in revenues.

Now suppose that decoupled payments are paid on the mandatory 15 percent increase in flex-acres, equal to 50 percent of the foregone income, or $2,250. In addition, optional flex-acres are reimbursed at 90 percent of foregone income. If the farmer enrolled a total of 50 percent of base in such flex-acres (an additional 20 percent or 60 acres) at 90 percent of the previous payment, he would receive $5,400. Finally, suppose that decoupled "green payments" were made on all of the mandatory flex-acres (90 acres) plus the voluntary flex-acres (60 acres), equal to 150 acres, in return for an expanded rotation including oats and some fallow in what had previously been a strict corn/soybean rotation. This approved rotation would receive an additional .20 cents per acre per year assuming 100 bushel yields, equal to $3,000.

On net, the farmer would reduce his income due to mandatory flex-acres by $2,250, and due to voluntary flex-acres by $400, but would receive an additional $3,000 in green payments, leaving him with a net gain of $340. The consequence of the flex-acre addition applied to all corn base would probably be to reduce excess supplies, making an ARP less likely, although it could still be applied to the remaining 50 percent of base.

Now suppose that a new CRP contract is offered at 75 percent of the previous bid price (in this case $75) for high pollution-to-output designated acres with this farm's productivity potential, and that acres not so designated could be returned to base. Of the 100 acres in the CRP, 50 percent are determined eligible for a continuing contract or easement, equal to a continuing revenue stream of

50 X (.75 X $75) = $2,812.

Since 50 acres are returned to base, the calculations above would need to be redone. If the same percentages applied, then total base would be 300 + 50 = 350, of which 15 percent would be uncompensated flex-acres, a mandatory additional 15 percent would be compensated at 50 percent, and 20 percent voluntary flex-acres would be compensated at 90 percent. In addition, green payments on all of the flex acres would be paid at .20 cents per acre, and a CRP contract on the remaining 50 eligible acres would pay 75 percent of the previous bid price, or $56.25.

In sum, the effect of the green payments would be as below.

- Total new base = 350 acres
- Total eligible for CRP = 50 acres
- Existing mandatory flex-acres = 15 percent = 52.5 acres
- Additional mandatory flex-acres = 15 percent = 52.5 acres
  @ .50 cents per acre X 100 bushels/acre = $2,625
- Voluntary flex-acres = 20 percent = 70 acres
  @ .90 cents per acre X 100 bushels/acre = $6,300
- Green payments on all flex-acres = 50 percent = 175 acres
  @ .20 cents per acre X 100 bushels/acre = $3,500
- CRP payments on 50 acres
  @ 75 percent of $75 = ($56.25 X 50) = $2,812

- Continued Deficiency Payment on 175 acres @ $1 per acre
  X 100 bushels/acre = $17,500
- Total Decoupled Income Assurance on Flex-Acres $8,925
- Total Green Payments $3,500
- Total CRP Payments on New Contract $2,812

- TOTAL PAYMENTS $32,737

It should be noted that this compares to an assumed status quo payment of

- Total base = 300 acres
- Total in CRP = 100 acres
- Existing mandatory flex-acres = 15 percent = 45 acres
- Deficiency Payment = (300 acres - 45 flex-acres)
  X $1 per acre X 100 bushels/acre = $25,500
- CRP Payment = (100 acres X $75 per acre) $7,500

- TOTAL PAYMENTS $33,000

In short, the proposed reforms in this hypothetical example are essentially budget neutral. Reductions in support due to additional planting flexibility and CRP retrenchment are offset by green payments. What has changed, in a major way, are the incentives linking farm income support programs and environmental improvements.

Footnotes

[1] The neutral case is not due to Schelling, but has been added for completeness.

[2] This study does not explicitly cover the incentive effects of a wide variety of federal marketing orders for fruits and vegetables, although the policy prescriptions in the conclusion could apply to many lands devoted to such uses.

[3] Steps in this general direction are already occurring. As a result of 1990 FACTA, the USDA changed CRP bid evaluation procedures to screen all bids against productivity-adjusted dryland cash rent. Thus, bids that are higher than the county average dryland cash rent, adjusted up or down based on the ratio of the county average to the soil-specific yield of a reference crop, are rejected. Bids that pass this rent screen are then ranked according to an environmental benefits index (EBI) per dollar of rent asked and the best land chosen. Thus, cheaper land with lower benefits may be competitive with more expensive land that has high environmental benefits. However, environmental benefits cannot be quantified in dollar terms, although the rent screening and EBI ranking are an improvement over procedures used for the first 9 CRP signups (Heimlich, 1994a).

Designing A Successful Voluntary Green Support Program: What Do We Know?

By Sandra S. Batie

INTRODUCTION

The current debate surrounding the reauthorization of omnibus farm legislation has refocused policy makers' attention on an expanding set of public goals envisioned for the Farm Bill. Whereas early Farm Bills mainly addressed farm income goals, recent Farm Bills have given increasing attention to environmental quality concerns. For example, the 1985 Farm Bill, (The 1985 Food Security Act), created the Conservation Reserve Program which explicitly addressed soil erosion and water quality problems as did the "Swampbuster", "Sodbuster" and Conservation Compliance provisions in the same Act. The 1990 Farm Bill, (The 1990 Food, Conservation and Trade Act) added additional environmentally-oriented programs: the Wetland Reserve Program, the Water Quality Incentives Program, and the Integrated Farm Management Program.

At the same time, there has been a proliferation of local, state, and federal legislation addressing agriculture's nonpoint pollution problems and natural resource protection. This legislation has catalyzed public debates on inconsistent legislative "signals" to producers, the number and fragmentation of programs, as well as the public and private costs of compliance. These debates have resurfaced the concept of Green Support Programs (GSPs). Attractive in principle, a GSP is based on the pursuit of two public goals—(1) farm income support and (2) environmental protection—with one policy instrument. The policy instrument is the provision of monetary payments to producers who pursue some environmental goal. The basic concept is not new, but is refined in current discussions by consideration of a GSP designed to obtain more environmental quality per program dollar than has been the case in the past.

Refinement of the GSP concept is possible because there is now data that can serve as indicators of the location, nature, and magnitude of environmental problems (Heimlich, 1994b). The data show that the character of nonpoint environmental problems differ in source and impact, and that these problems are unevenly distributed throughout the nation. That is, the problems of confined animal waste pollution of water in some counties in Pennsylvania differ from the problems of nitrate pollution of groundwater from crops in some counties of Nebraska, which differ from the problems of air pollution due to wind erosion of exposed cropland in some counties in Texas, which differ from the problems of chemical and toxic contamination of reservoirs in some counties in California. Some regions have severe agricultural-related environmental problems; others do not.

Sandra S. Batie is the Elton R. Smith Professor of Food and Agricultural Policy, Department of Agricultural Economics, Michigan State University, East Lansing, Michigan. *Thanks are due to: Tom Dobbs, Ralph Heimlich, Sarah Lynch, Ford Runge, Jerry Skees and Katherine Smith for their helpful counsel in the preparation of this paper.*

Having data available means that, now, more than ever before, program managers can identify and target payments to those producers who could improve environmental quality the most, if they were to change their farming systems or farming practices. These producers may not necessarily be the same ones currently receiving farm income support payments, however. Thus the politically acceptable design of a GSP is quite complex (Lynch and Smith, 1994).

Even if the difficulties of the political acceptability of a GSP were resolved, however, there still remains additional complexities. If agencies were to use existing data to target priority watersheds or airsheds with significant nonpoint pollution problems, as well as to target priority farms within these priority watersheds and airsheds, are there viable solutions for producers who are participating within a voluntary GSP? Questions to be addressed in the remainder of this paper include:

- Do farm-level "solutions" to non-point environmental problems exist?

- What factors will cause farm-level "solutions" to be implemented by producers on targeted farms within targeted watersheds or airsheds?

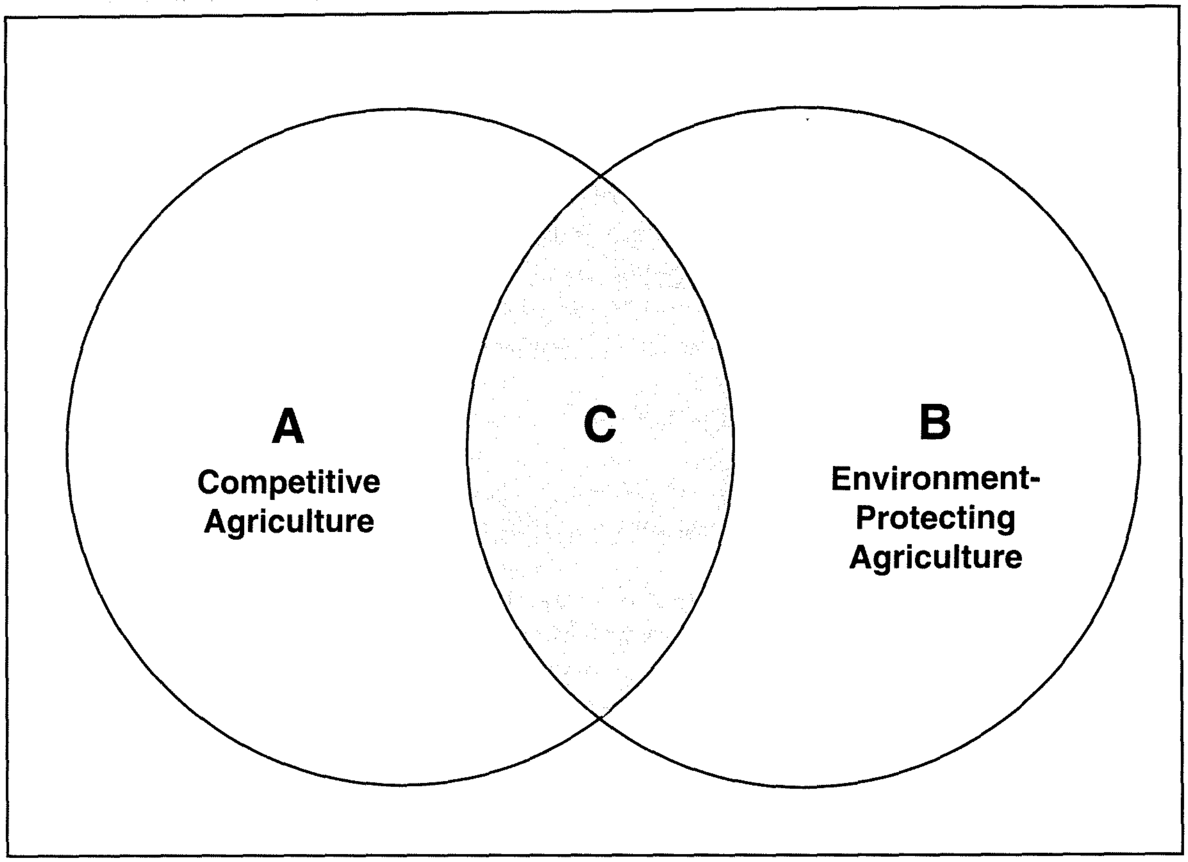
The design of a truly successful voluntary green support program will require careful attention to these questions. Presumably, the goals of a GSP are to improve environmental quality by changing farming systems without handicapping the competitiveness of American agriculture in a global economy. A voluntary program must therefore be seen by producers as a viable choice, given producers' resources, farm characteristics, attitudes, and constraints. There must be alternative technologies available to the producer, and these technologies must be used in such a way and on such farms that environmental quality is actually improved.

Thus, a successful voluntary GSP must identify and target the location of environmental quality problems related to agricultural uses of the land. Technologies and information must be available that improve the situation. Producers must be persuaded to voluntarily adopt these systems or practices. This study will address the latter two components: agricultural technologies to improve environmental quality and the voluntary adoption of these technologies.

Do Technologies and Information Exist for Farm-Level Improvement of Nonpoint Pollution Problems?

A successful voluntary GSP will need to identify which alternative farming systems (or practices) meet both the criteria for general profitability (perhaps with a modest green support payment) as well as for the improvement of environmental quality. Put succinctly, a successful GSP needs to identify the practices and systems that are represented by the shaded intersection of the Venn Diagram representation in Figure 1.

Figure 1. Technology and Information Choices



Plans versus Practices

Agricultural practices and farming systems represented by the shaded intersection in the Venn diagram can differ for different farm situations. Thus, while it is tempting to focus a GSP toward the adoption of single, individual farming practices such as a Best Management Practice (BMP), it is not ideal. Not only are producers, farms, and regions diverse, so that individual practices are not suitable for every situation, there are also many inherent linkages between soil quality, the use of inputs, and the impact on the environment and profits. As a result, more environmental quality will be obtained by more careful tailoring of GSP supported farming systems or practices to individual farms. However such a tailored approach does increase program complexity and implementation costs.

One approach might be for a GSP to require a whole farm plan of participants in lieu of implementing BMPs. Such a plan could incorporate an analysis of the linkages between soil quality, input use, profits and environmental quality and could be provided by federal, state or local public agencies (e.g., Soil Conservation Service, State Departments of Natural Resources, Cooperative Extension Service), by private consultants, or as an additional service from agricultural input dealers[1].

A flexible, farming systems analysis that recognizes these linkages can result in the identification of a lower cost, more effective solution to an environmental problem than can the dictation of a BMP which addresses only one aspect of the farm[2].

The planning process itself can also be the source of valuable information for the producer with respect to environmental quality impacts of various farm management decisions[3]. A farming systems analysis can also highlight tradeoffs between alternative practices. For example, the reduction of phosphorus in sediment can lead to an increase of phosphorus in the soluble form; the use of rotations can reduce profits; reducing pesticide runoff can increase pesticide leaching; or the reduction in stream sediment can decrease stream channel stability. A farming system analysis, where the tradeoffs in farm related environmental problems are identified, can result in better choices.

Dynamic Relationships

It is important to realize that the Venn diagram in Figure 1 is dynamic. First, the very logic of a GSP is to use payments to enlarge the shaded intersection of both profitable and environment protecting farming practices and systems. That is, a GSP might provide payments for farming practices that are not profitable from a producer's perspective but will yield significant environmental quality benefits.

In addition, the shaded intersection can expand over time as the research community increases its focus on the environmental quality impacts of agriculture. Traditionally, agricultural research has focused mainly on increasing the quantity of output, such as crop yields. More recently, there has been increased research attention to reducing the amount of chemical inputs and to the reduction of soil erosion. The result has been more technologies that are both environmentally protecting and which maintain the competitiveness of U.S. agriculture. Integrated Pest Management is an example of such a research effort; as are many technologies that have been termed "alternative agriculture" technologies.

Are there currently enough technologies that are either both profitable and environmentally protecting or which could be made so with a modest GSP payment? The answer appears to be "yes", at least in many cases. A complete review of these technologies is not possible in this brief overview. However, a recently completed review of the science associated with improving soil and water quality by the National Research Council (1993) identified four fundamental principles for national policy to improve soil and water quality as well as agricultural practices and systems that could be used to pursue the goals of improved environmental quality. Many of these would be either profitable or low cost for many producers.

Fundamental Principles

The four principles for improving environmental quality from the National Research Council report are:

> National policy should seek to (1) conserve and enhance soil quality as a fundamental first step to environmental improvement; (2) increase the nutrient, pesticide, and irrigation use efficiencies in farming systems; (3) increase the resistance of farming systems to erosion and runoff; and (4) make greater use of field and landscape buffer zones (p. 4).

The National Research Council report identified various changes in farming practices that could be used to implement policy that embraced the four principles[4]. For example, there is considerable evidence of excess nitrogen use (compared to plant uptake) in many regions of the country. Where there is excess nitrogen, improved environmental quality could result from better record keeping, proper accounting for sources of nitrogen, soil testing, proper yield goals, and the synchronizing of nitrogen application with crop needs. Within a watershed, coordination among farms and the use of whole farm nutrient management plans could, in many cases, achieve a significant reduction in residual nitrogen (National Research Council, 1993).

There is also evidence of excessive phosphorus in many soils. Yet additional phosphorus is sometimes applied, frequently as a result of the spreading of manures. Because phosphorus binds to sediment, phosphorus loss can be reduced by reducing soil erosion as well as by reducing applications. Improved practices that may be viable in some phosphorus rich regions include the use of buffer strips, planting cover crops, storing or hauling of manure, or planting a more diverse set of crops (National Research Council, 1993). Similarly, irrigation practices can be improved on some farms by better water scheduling, optimal allocation rates, the reuse of drainage waters and similar practices (National Research Council, 1993).

The improved management of pesticides is also possible. There is no perfect pesticide—that is, one that adequately controls only the target pest and then suddenly dissipates leaving no harmful residuals in the environment (National Research Council, 1993). While many believe that American agriculture could reduce pesticide use, the total elimination of pesticides in a short period of time would cause major disruptions in the agriculture sector (Gianessi, 1993). These disruptions would result from the lack of readily available substitutes and technologies for all situations and enterprises (Gianessi, 1993). If the public goals were to ultimately reduce pesticide use after a transition period, however, the search for substitutes would focus research attention on the development of alternative systems to a much greater degree than has hitherto been the case. Such long term efforts to reduce the need for environmentally damaging pesticides are the most promising approach to reducing environmental damages from pesticides (National Research Council, 1993).

While total elimination of pesticide use would be extremely disruptive at this time, there currently are available technologies, farming systems, and farming practices that can reduce pesticide losses to the environment for many types of agricultural systems in many regions (National Research Council, 1993). A GSP could focus attention on these situations and encourage alternative systems that reduce pesticide use where there are pesticide pollution problems, particularly when a green payment would make adoption of these practices and systems more attractive to the producer.

The basic principles to be followed in reducing the use of pesticides include:

- selection of proper pesticides and formulations;
- improved timing and application methods to minimize drift and volatile losses;
- use of erosion and runoff control measures to reduce losses through runoff and leaching;
- use of nonchemical pest control measures such as crop rotations and management; and
- integrated pest management (which embodies most of the recommended practices cited above) (National Research Council, p.329).

The Role for Alternative Agriculture

In some cases, the agricultural technologies and systems that reduce chemical inputs and/or improve environmental quality are classified as belonging to "alternative agriculture". Although sometimes the concept of alternative agriculture incorporates a philosophy of being in "harmony with nature" (as opposed to the more conventional "management of nature") (Batie and Taylor, 1991), it more frequently refers to alternative practices or alternative systems regardless of underlying philosophies. Indeed many farms employ neither totally conventional nor alternative systems, but are more-or-less "conventional" or "alternative" in their main tendencies (General Accounting Office, 1990). Farmers who adopt reduced input systems frequently do so to solve a particular production, environmental, or health problem as opposed to doing so for philosophical or ideological reasons (Buttel, et al., 1986).

The General Accounting Office report, *Alternative Agriculture*, summarizes the differences between some conventional and alternative practices (Table 1) (General Accounting Office, 1990, p. 32). While organic practices are considered alternative agricultural practices since they use no purchased chemical inputs, there are many practices that are low-chemical but not organic. These include practices that use diverse rotations, biological pest control, or conservation tillage methods.

Alternative agricultural practices are so-named because, if used properly, they are more environmentally protecting than conventional agricultural practices. Much of the debate surrounding widescale adoption of alternative agricultural practices however does not relate to their environmental impacts, rather, the debate relates to their profitability.

Table 1. Characteristics of Alternative Agriculture Practices

Agricultural Component	Conventional Practice	Alternative Practice
Crop Choice	Specialize: plant most profitable crop on same ground year after year	Increase diversity, use multiyear rotations, and develop integrated crop and livestock operations
Pest and Weed Control	Apply synthetic insecticides, herbicides, and fungicides	Use Integrated Pest Management, natural predators, resistant crops, crop varieties well-suited to agronomic conditions, crop rotations, mechanical cultivation, and intercropping
Soil Cultivation	Cultivate highly prepared seed beds	Maintain protective cover on soil and plow to minimize soil erosion and loss of soil moisture

Source: General Accounting Office, 1980, p. 32.

Profitability Factors Influencing Participation in a GSP

Agricultural practices and systems exist that are more environmentally protecting than many current conventional practices and systems. But how many are profitable or could be made profitable with a modest green support payment? The profitability of alternative agriculture has been long debated (see for examples, Buttel, et al., 1986; Council for Agricultural Science and Technology, 1990; Crosson and Ekey, 1988; Dobbs, 1993; Dobbs, 1994; Fox, et al., 1991; General Accounting Office, 1990; Natural Resource Council, 1989; Tweeten, 1992). A careful reading of the arguments and the evidence suggest that there are alternative practices that do reduce negative environmental impacts from conventional practices in some, but not all, circumstances. Some, but not all, are profitable or relatively low cost[5].

The distinction between alternative and conventional agriculture may not be as useful for the purposes of this paper as is the distinction between which farming technologies and systems provide both public and private benefits. Return to

Figure 1 and consider that those practices and systems in Circle A — Competitive Agriculture — but not in the intersection C are those that yield private agriculture industry profits but are not environmentally protecting. Similarly, those in Circle B — Environmentally Protecting — but not in the intersection C are those that yield the public benefits of improved environmental quality but are not profitable. Those in the shaded intersection yield both private and public benefits (beyond a food supply).

Pampel and van Es (1977) make the distinction between technologies that are commercial innovations — that is those that improve profits (i.e., in the portion of Circle A not in the intersection) and those that are environmental innovations (i.e., in the portion of Circle B not in the intersection) — that is, they have as a first objective the protection of an existing natural resource. The means and goals of these two types of technologies are sufficiently different and imply different adoption behaviors; and they will also, therefore, imply different GSP payment policies (Camboni, Napier and Lovejoy, 1990).

One way to categorize farming systems in a manner that encompasses this distinction between commercial and environmental technologies is to adopt a producer's point of view of the perceived outcome of adoption. Will there be a positive private outcome from adoption? Whether the farming system is perceived as a profitable system may not be the sole factor, but for many producers it will be the dominate factor. At the same time, the perception of the adoption of the proposed farming system on a desired public good such as environmental quality is important too. Where the producer perceives a positive outcome for both himself (or herself) and the public, adoption will be more readily forthcoming. Furthermore, if the perceptions are accurate, the system will remain in place (that is, there will be no reason for the producer to abandon the new farming system and return to former practices). Perceptions will also be weighted by the producer in ways to account for uncertainty of outcome. The more uncertain the producer perceives the outcome, the more likely will be the presumption that it will be negative.[6] Table 2 displays these categories in matrix form.

Win-Win

In the Table 2 matrix, the northwest cell identifies a farming system (or a farming practice) that is termed "win-win". That is, the producer views the system to be profitable and to fit within the acceptable range of other socio-economic constraints and goals; the producer also perceives the system to produce positive public environmental benefits. An example might be a nutrient management plan that both reduces the purchase and use of commercial fertilizers, but does not negatively impact yields (National Research Council, 1993). For these types of systems, voluntary, targeted GSP programs have great potential to change behavior since the producer should have an incentive to adopt them. However, educational programs and transitional cost-sharing may be required even in "win-win" situations. The decision to change behavior should be stable and continued cost sharing should not be necessary to maintain the system or practice.

Table 2. Producers' Perceptions of Technological Impacts and GSP Payment Implication

Perceived Public Outcome	Perceived Private Outcome	
	Positive (Profitable)	Negative (Unprofitable)
Environmental Gain	Win-Win: Transitional GSP Payments to Adopt Technology	Lose-Win: Continual GSP Payments to Adopt Technology
Environmental Loss	Win-Lose: Continual GSP Payments to Avoid Technology	Lose-Lose: No GSP Payments

There are models of promising state-level programs from which to draw lessons. For example, Iowa has had a program to improve nitrogen management since 1982. In the Big Springs Basin in Iowa, a combination of education, technical, and financial assistance resulted in 52 percent of the producers reducing their application of nitrogen fertilizer compared to the decade earlier. State wide demonstration projects were an integral part of the program (National Research Council, 1993). "The experience in Iowa suggests that aggressive, coordinated efforts can accelerate the voluntary adoption of improved farm management techniques, at least when improved management results in financial as well as environmental benefits (National Research Council, 1993, p. 170).

It is probable that there are systems and practices that belong in this northwest cell, but that are not yet so perceived by producers. For example, there are numerous studies that suggest that many producers do not view a reduction of chemical use or other alternative agricultural practices as compatible with profitability goals. In a Wisconsin study, for example, 71 percent of the farmers felt their yields would drop if chemical inputs were reduced. And in an Iowa survey half the respondents felt that the increased costs of tillage, labor, and machinery would cancel any savings from reduced herbicide use (U.S. Congress, 1990). Not all of these impressions are accurate, and thus a targeted and tailored educational/demonstration program would seem to be needed to change perceptions and accelerate adoption.

Lose-Lose

The southeast cell in Table 2 can be termed a "lose-lose" situation as perceived by the farmer. The producer has no incentive to adopt this farming system or practice nor does he or she perceive it to have positive effects on the environment. Assuming these perceptions are accurate, this situation is stable and no adoption will take place, nor should it. No GSP payment should go to these practices.

Win-Lose

The southwest cell, on the other hand, represents a situation where the producer perceives a positive outcome from the adoption of the system (or practice), but there is a negative public outcome (win-lose). The farming of fragile highly eroding soils, intensive chemical use near waterways, concentrated livestock production near waterways could be practices in the southwest cell. Clearly no GSP payment should be available for this system (or practice). However, changing behavior so that this system (or practice) is abandoned is more problematic in a voluntary program. Such changes may require continual cost sharing incentives—perhaps backed up with the threat of future regulation. Of course, cost sharing programs must be carefully designed in these cases. If too small, they will not elicit the desired changes; if too large, they create windfalls for producers and lead to public opposition.

Here too there may be a need for educational programs if the producer fails to perceive a negative impact on the public benefit—either from his or her farm or in general. Thus, the producer may perceive a system or practice belongs in the northwest "win-win" cell when in actuality it is the southwest "win-lose" cell. Some extension agents have claimed success with an educational technique that involves actually sampling the runoff or leaching from a farm enterprise for contaminants and sharing the results with the producer within the context of overall pollution of nearby water so the producer will recognize the farm's contribution to water quality degradation (Tompkins, 1994).

Lose-Win

The analysis of the northeast cell is similar to the southwest cell. Whereas the southwest cell requires a cost sharing approach to have a producer replace a environmentally damaging system with a more environmentally supportive one, the northeast cell, involves encouraging a producer to adopt a practice that may be perceived as harmful to his or her profit goals, but protective of the environment (lose-win). Such practices might include for example the adoption of filter strips or the setting aside of land for the protection of wildlife habitat. Here again long term cost sharing or other payments will be needed in a voluntary GSP.

One approach currently being used in Wisconsin to get voluntary adoption of wind erosion control practices that most likely fall in the northeast cell is "The Conservation Credit Initiative". Producers in the Central Sands area receive a $3 to $5 credit per acre on their property tax bill for each acre voluntarily enrolled in a Conservation Credit Program. The program has also been expanded to include Pepin County dairy producers for the adoption of water quality protection practices. The credits are incentives to those who farm their own land, and the program has positive attributes of rewarding good stewards, being locally directed, and being flexible[7].

Which Technologies Where?

As previously discussed, the determination of which technologies and which farming systems and practices belong in which cell requires a careful analysis that is unique to the particular watershed, airshed, and farm in question. However, the evidence suggests that, for many, perhaps most situations, there are both win-win systems (and not yet adopted) or unexploited opportunities to change lose-win situations into win-win situations with modest public payments. Furthermore, foreseeable research results should expand such opportunities. However, success in a GSP program depends not only on the accurate identification of those opportunities, but also on overcoming other non-profitability barriers to participation in a GSP.

Non-Profitability Factors Influencing Participation in a GSP

There is considerably more known about which farming systems should reduce environmental degradation, then there is known about why individual producers farm the way they do. This ignorance is partly due to inadequate research directed to the question.

However, another reason for this ignorance is the complexity of the answer. This complexity stems from the diversity of agriculture in the United States. This diversity includes the variation in soils, landscapes, climates, and hydrogeology in which farming takes place; the variation in the type, size and ownership of the farming enterprise; and the variation in the socioeconomic motivations and characteristics of producers. There is also variation in the institutional settings, signals producers receive from markets, policies, and information suppliers (Creason and Runge, 1992; Fletcher, 1986; Soil and Water Conservation Society, 1993).

A recent study by the Office of Technology Assessment (U.S. Congress,1990) provided a summary of the research on diffusion of conservation innovations and the factors influencing producers' decisions with respect to farming practices (See Table 3). Several of these findings appear to be particularly germane to the successful participation of producers in a voluntary GSP, particularly those findings relating to perceptions of the source and magnitude of environmental problems, attitudes about the value of environmental goals, and producer involvement in program design. The successful design of a voluntary GSP will depend on understanding producers' motivations for adoption of appropriate farming systems in these complex and heterogenous settings.

Table 3. Research Findings on the Diffusion of Conservation Innovations[8]

1. Farmers are a heterogeneous group with unequal abilities and unequal access to information and resources for decisionmaking. Farmers vary in their objectives, level of awareness, use of information, and willingness to take risks; factors strongly influencing some farmers may have very little effect on others...

2. Farmers' decisions are based on their fundamental reasons for farming; their objectives may not be clearly defined or articulated. Farmers' objectives include: making a satisfactory living (either as an owner-operator, tenant, or employee); keeping a farm in operation for family inheritance or other personal reason, perhaps while working at an off-farm job; obtaining a satisfactory return on investments in land, labor and equipment; obtaining tax benefits from the farm; obtaining recreation or esthetics enjoyment from the farm; or a combination of these.

3. Economic factors exert important, but not sole, influences on farmer decisionmaking. Economic factors are key in defining what is financially possible for farmers, but a variety of personal, cultural, and environmental factors also shape farmers' decisionmaking....

4. Farmers typically make production decisions within short time frames, which discourages investments in resource protection measures. Farmers often are forced to make decisions within a short-term, year-to-year planning horizon that can prevent them from taking risks or making the most economically efficient decisions over the longer term....groundwater contamination are more complex than individual BMPs (Best Management Practices) or technological products. Complexity of systems-oriented changes will slow their adoption.

5. Farmers make changes slowly. The decision to change farming practices requires a considerable degree of deliberation, and maintaining new changes frequently necessitates on-farm experimentation and adaptation beyond that conducted during initial technology development....

6. A farmer's innovation decision process consists of several sequential states. These proceed through: 1) knowledge,... 2) persuasion,...3) decision,...4) implementation, and 5) confirmation.... Farmers need different kinds of information and use different communication channels at each stage....

7. Farmers adopt "preventive innovations" more slowly than "incremental innovations." Agricultural innovations studied in most diffusion research have been "incremental innovations," or ideas adopted in the present (e.g. hybrid corn, commercial fertilizers) to gain possible increases in value in the future.... "Preventive innovations" are new ideas adopted in the present to avoid possible loss in the future.... Adoption rates of preventive innovations usually are slower than those for incremental innovations....

8. Individual and farm characteristics appear to explain only a small portion of conservation adoption behavior; institutional factors (e.g. farm programs, credit availability) probably are highly influential.

Table 3 continued . . .

9. Studies on adoption of farm practices have rarely examined the physical settings of adoption decisions or the extent of resource degradation as it relates to adoption of remedial farm practices.

10. Farmers tend to underestimate the severity of soil and water quality problems on their own farms.

11. Farmers are most likely to adopt technologies with certain characteristics. Favored technologies are those that: 1) have relative advantage over other technologies (e.g., lower costs, higher yields); 2) are compatible with current management objectives and practices; 3) are easy to implement; 4) are capable of being observed or demonstrated; and 5) are capable of being adopted on an incremental or partial basis....

12. Decentralized information exchange among farmers promotes a wider range of innovations than do more centralized diffusion channels. Diffusion research indicates that local social networks are more important in the dissemination of preventive innovations than they are in incremental innovations....Farming changes to protect groundwater will likely be facilitated by decentralized farmer-to-farmer information exchange...

"No Problem on My Farm"

One reason producers are unwilling to participate in environmentally-oriented programs is that they fail to see that they are part of a problem that requires remediation. Several studies suggest that while farmers are aware of water quality or soil erosion problems as a serious national or local problem, they tend to exempt their own operation as contributing to the problem. While in some cases this exemption may be warranted, studies indicate that many producers underestimate their actual pollutant loadings to water or their actual soil erosion rates (Bosch, et al., 1992; Nowak, 1982; Napier, Camboni, and Thraen, 1986; Camboni, Napier, and Lovejoy, 1990; U.S. Congress, 1990). That is, there appears to be little correlation between the physical characteristics of the producer's farm and his or her perception of an environmental problem or choice of farming practices (Nowak, 1987).

These findings appear to hold even when a program is accompanied by cost-sharing incentives. Hoban and Wimberly (1993) found that one quarter of the nonparticipants in 21 Rural Clean Water Program (RCWP) project areas did not participate despite cost sharing of practices because they did not believe water pollution was a problem on their own farm. These perception existed despite the deliberate selection of RCWP in areas having water quality problems (Mass, Smolen, and Dressing, 1985). In addition, six percent said that cost shares were too low or cited other deterring financial factors. Fifteen percent resisted participation because changing practices would be too much trouble, involve too much red tape, or be too complicated. Ten percent had never heard of the program.

Similar studies have found that farmers failed to participate in the Conservation Reserve Program because they believed they were ineligible, when in fact their land would have qualified. Esseks and Kraft (1986) found in a national survey of farmers that the most frequently cited reason (41 percent) for farmers not entering a bid into the CRP was that they thought their land was not eligible. This figure compares with 25 percent who thought the rental payments were inadequate and the 30 percent who thought the ten year contract period was too long.

Lack of knowledge of a program and the lack of cost-sharing is frequently cited in studies as reasons for nonparticipation in a program (Ligon, et al., 1988). Ligon and her colleagues (1988) study of Chesapeake Bay farmers found that small, part-time, or absentee farmowners were less likely to know about the existence and eligibility requirements of the Conservation Reserve Program.

There is some evidence that producers already enrolled in commodity programs are more likely to be aware of new programs, such as the Conservation Reserve Program (Camboni, Napier, and Lovejoy, 1990). This correlation implies that, if there is to be voluntary improvement in environmental quality stemming from practices of nonparticipants in commodity programs, then there needs to be a specifically tailored outreach program to this audience. Commodity program participants such as grain farmers appear to have more access to information on cost sharing programs than, say, livestock producers. If the target problem is animal waste runoff, then specific information will need to be targeted to livestock producers.

Esseks and Kraft (1990) as well as the National Research Council (1993) recommended that these educational programs be modeled on what they termed an "industrial marketing" approach that "sells" a tailored best management system by relating the system to the goals and objectives of the "buyer" (i.e. farmer). This selling is accomplished by using techniques not unlike those used in "Madison Avenue" advertising campaigns for normal consumer goods. Targeted and tailored information is crucial for a voluntary program. As Padgitt and Lasley (1990) note in writing about conservation compliance "mass approaches and trickle down education are not likely to meet the needs..." (p. 398).

Attitudes

Attitudes toward the environment in general can influence adoption. For example, Purvis, Hoehn and Sorenson (1989) found that farmers who are concerned about the environment are likely to set aside more of their eligible acreage in filter strips or to require lower yearly payments for participation. Farmers who indicated they were not concerned about the environment would require a yearly payment approximately $35 per acre higher than those who consider environmental quality an important reason to enter a filter strip program.

Similarly, Napier and Brown (1993) found that farmers who believed that pesticides and fertilizers in groundwater posed a threat to family health tended to perceive that groundwater pollution was an important environmental issue. They were also more willing to "force" farmers with legislation to use groundwater protection practices.

Thus, it appears that a perception of a problem is a logical prerequisite to adoption of changed systems of practices (Norris, 1985; Ervin and Ervin, 1982; Napier and

Forester, 1982; Ervin and Alexander, 1981; Hoover and Wiitala, 1980; Nowak, 1982). Nowak and Korsching (1983) as well as Bosch, et al. (1992) found that there is a negative correlation between the perception of both water quality and soil erosion problems and the years of experience in farming. The more experienced producers tend to underestimate their contribution to an environmental problem. Similarly, in a study of 570 North Carolina farmers, Anderson (1988) found that full time farmers with more agrichemical intensive operations expressed significantly less concern about chemicals potential to harm wildlife than did those farmers who had less intensive operations. These findings are consistent with study results in Virginia (Halstead, Batie, and Kramer, 1988; Halstead, Padgitt and Batie, 1990) and Iowa (Padgitt, 1987). However, in general, individual and farm characteristics explain only a small portion of differences in adoption behavior (Napier and Brown, 1993; U.S. Congress, 1990).

Other studies have shown that the number of contacts producers have with various sources of technical and education assistance was positively related to accurate perceptions of erosion problems (Choi and Coughenour, 1979; Hoban, 1990; Nowak and Korsching, 1983; Ervin and Ervin, 1982).

These factors influencing producer decisions imply that a targeted voluntary GSP will need to be accompanied with a tailored educational component so that producers recognize the severity and nature of the environmental problem as well as their contribution to it. However, studies of environmental problems show that environmental problems are unevenly located in various regions and parts of regions throughout the nation. If producers are to recognize their contribution to an environmental pollution problem, there needs to actually be a problem. Broad general assertions that imply all farms contribute to equally severe environmental problems are not only inaccurate, they tend to reinforce attitudes of "not on my farm." Targeting to genuine and more severe environmental problems such as the loss of important wildlife habitat, the extinction of endangered species, the imperiling of human health or recreational benefits, or the destruction of long term productivity will increase the credibility of using voluntary technical and financial assistance.

Producer Involvement

Even if a producer is aware of a problem, he or she must still have a favorable attitude toward the proposed solution if they are to voluntarily adopt a new farming system or practice (Lovejoy and Napier, 1986). Some researchers argue that adoption will be increased if there is producer involvement in both problem definition and problem solution. For example, J.C. van Es (1982) notes:

> This undoubtedly sounds trite, but soil and water conservation programs have a history of defining a physical problem, developing a technological solution, and then devising a way to have the solution implemented by the farmers. Heavy reliance on voluntary approaches will require that farmers be involved much more actively in problem definition and problem solution than has traditionally been the case (p. 250).

Given the diversity of site-specific problems, failure to involve producers will undermine cost-effective solutions. Furthermore, if producers assist in problem definition, they are more likely to carefully implement changes. One outcome of producer involvement, then, is reduced program implementation and enforcement costs. The involvement of producers is also essential for tailored educational components that should underlie a targeted voluntary GSP.

Can A Voluntary GSP Achieve Improved Environmental Quality?

Even if producers are involved, perceive a problem, and participate in concentrated, tailored educational activities, voluntary programs will not achieve improved environmental quality by themselves, except perhaps in the win-win situations.

Many believe that voluntary programs alone, at least as currently designed, will not accomplish all the desired environmental goals (Batie, 1983; Buttel and Swanson, 1986; Harrington, Krupnik, and Peskin, 1985; Hoban, 1990; Napier, 1987; Swanson, Camboni, and Napier, 1986). Epp and Shortle (1985) note that voluntary actions for most environmental problems have not been very successful. After a review of the Wisconsin Nonpoint Source Water Pollution Abatement Program, Konrad and his colleagues (1985) conclude that "no voluntary program will achieve the desired levels of control in all situations. In those cases, regulatory mechanisms must be considered" (1985, p. 61).

Similarly, the Chesapeake Bay program review panel concluded that voluntary incentives, at least as implemented in the past, have been ineffective in achieving program goals (Nonpoint Source Evaluation Panel, 1990). Surveys also suggest that many farmers want some coercion to penalize non-compliers with environmental legislation (Padgitt and Lasley, 1993), so that historical and consistent "bad actors" are not rewarded for their behavior.

Harrington, Krupnick, and Peskin (1985) note that those nonconservation, voluntary programs that have been successful in the past share common elements:

> The first condition is agreement that the policy objective is a worthy one and that the action sought will advance that objective. The second is easily observable noncompliance in order to create social pressures for compliance. The third is that the cost of a voluntary approach should not greatly exceed the value of its private benefits. The fourth is a belief that failure of the approach will eventually lead to mandatory action (p. 28).

Thus, there may be a need for a perceived threat of additional governmental action if the voluntary nonpoint pollution programs fail to achieve satisfactory results[9].

There appear to be few voluntary non-point programs which are designed using these criteria for their success, in part because many non-point programs are based on earlier conservation programs characterized by pursuit of farm income support goals (Batie, 1985).

Implications for a Green Support Program

What do we know about designing a voluntary GSP that improves environmental quality? For many farming situations appropriate technologies and information exist to achieve more "environmentally protecting" farming, but environmental problems are unevenly distributed nationally as well as within watersheds and airsheds. Furthermore, successful voluntary programs tend to occur where producers are aware of their contribution to an environmental problem they believe is important, where the benefits of participation are not swamped by the costs, where the producers have assisted in program design, implementation, and enforcement, where education programs are tailored to producer needs, and where an implicit or explicit threat of future regulatory programs exist (National Research Council, 1993).

These conclusions suggest some fundamental elements of a voluntary GSP. A voluntary GSP is more likely to be successful if it reflects the national diversity of problems and farm characteristics, that is, if it targets priority areas and priority farms within these areas, and if it emphasizes tailored site-specific planning processes with meaningful producer involvement.

One Size Does Not Fit All

The lesson from the diversity of the agro-environmental problems, the landscape, the farm enterprises, and the producers is: "One size does not fit all." Data on diversity and from the experience with other programs such as the Coastal Zone Act Reauthorization Amendments (CZARA) suggest that a single comprehensive program that specifies the adoption of specific practices for all farms would be ineffective and expensive. There is a public payoff in targeting to both "priority areas" and to "priority farms"—both in reducing the cost of the program and in improving environmental quality (National Research Council, 1993).

Heimlich (1994b) demonstrates the use of national data to focus attention on certain problems in certain regions. However, the national data are too aggregated to pinpoint precise watershed problem areas for local planning purposes. Nevertheless, there is increasingly refined data available at the state level to enable reasonably accurate identification of priority areas for a targeted GSP as well as for the identification of polluting farm enterprises within those priority areas. These data are in need of refinement (National Research Council, 1993), but such refinement could come in response to a targeted, voluntary GSP.

The payoff to targeting is the acceleration of the adoption of conservation systems in areas of most critical need, the maintenance of long term agricultural productivity, the reduction in off-site damages, and an increase in cost effectiveness. In addition, only those farmers who contribute significantly to environmental problems should be required to change their farming systems. By focusing on a priority area, the opportunity exists to provide flexibility in program design, to include producers in program design, and to strengthen the role of local and state agencies in coordination with federal programs (Nielson, 1986).

Equally important, is the ability provided by targeting to focus on different problems in different areas. Thus, in one region, such as the watersheds influencing the quality of the Chesapeake Bay, a major problem may be animal waste pollution. The targeted producer is then the livestock, poultry, or dairy producer. In other areas, such as the High Plains of Texas, the concern may be windblown dust and long term soil productivity. The targeted producer is then the crop producer.

Whole Farm System Planning

When reduced to its fundamentals, there are only three basic choices for the design a GSP: (1) the identification of a specific set of practices for each type of farm (i.e., design or technology based standards), (2) the articulation of a tailored site specific planning process, and (3) the specification of specific environmental quality goals (i.e., performance standards). The evidence concerning the factors that influence participation in a GSP as well as the diversity of environmental problems suggest that a voluntary GSP should focus on the development of a tailored site specific planning process. The development of targeted farm system planning is also the approach recommended by the National Research Council Committee that authored the report, *Soil and Water Quality: An Agenda for Agriculture* (1993).

Whole farm plans can be simple, but they do involve examining the whole farm as a system and changing how the producer gathers information and makes decisions. Plans, thus are information-gathering, recommendation-building exercises rather then a selection of management practices from a list of approved BMPs. Plans should be flexible and coordinate with the characteristics of individual enterprises. Integrated farm plans should focus on improving the way information is gathered and used by the producer to make farm management decisions. Indeed, standards such as record keeping or certification requirements intended to improve the flow of information may be far more valuable than technology-based standards (Batie and Cox, 1994).

Clearly, a voluntary GSP that relies on whole farm system planning cannot involve all farms everywhere; there are not enough resources to accomplish the job, nor is it necessary to do so. The importance of targeting to priority areas and farms within these areas is again emphasized.

There are some approximate models to use in developing this approach. For example, Wisconsin legislature created and funded the Wisconsin Nonpoint Source Water Pollution Abatement Program in 1978. The Wisconsin program concentrates on hydrological units called priority watersheds and areas within these watersheds termed priority management areas. Konrad, Baumann, and Bergquist (1985) describe this program. They note that six criteria are used to select the priority areas: (1) the severity of the water quality problem, (2) the magnitude of the loadings and the potential to reduce the loadings significantly, (3) landowners willingness to participate, (4) the ability and willingness of local agencies to assist the program, (5) and the capability of the local agencies to control pollution through the necessary enactments of local ordinances, (6) the potential public benefits and use from the proposed project. The selection process is quite specific and includes numerical rankings of watersheds. The priority watershed plan then has two parts: a technical assessment and an implementation strategy that outlines the process of achieving project objectives. These two parts are described in Table 4.

The National Research Council Report (1993) also provides a detailed discussion of the Narrows Creek Middle Baraboo Priority Watershed Project which is part of this

Wisconsin program. Dairying is the major activity in this watershed and the project was used to reach four priorities: (1) the appropriate use of soil tests, (2) nitrogen crediting from legumes, (3) nitrogen crediting from manures, and (4) construction of manure storage structures. Each of the three regions within the watershed required a different emphasis among the four general priorities (National Research Council, 1993, pp 164-166). Thus, the Wisconsin program contains many of the targeting, information-gathering, planning, and producer involvement elements discussed earlier.

Table 4. The Wisconsin Nonpoint Source Water Pollution Abatement Program[10]

Selection of Priority Watersheds
Selection of priority watersheds is a four step process that involves the numerical ranking of watersheds following evaluation by the Department of Natural Resources (DNR), review and recommendation by regional committees, the establishment of a list of 15 to 20 watersheds by a committee with various agency and interest group representation, and final selection of projects by the DNR.

Project Objectives
Selection of a priority watershed project is followed by an eight to nine year planning and implementation process. An Implementation plan is prepared based on a detailed inventory and assessment of critical source areas and the project's water quality objectives.

The priority watershed plan has two parts:

Part I. Part I is the technical assessment and the setting of the watershed project goals by (a) assessing water quality problems and objectives, (b) identifying significant nonpoint sources, (c) identifying water quality improvements that can reasonably be achieved through nonpoint pollution controls, and (d) identifying management needs.

Part II. Part II is the implementation strategy that outlines the process for achieving project objectives. It identifies (a) the tasks necessary to accomplish the management needs identified in Part I, (b) the agencies responsible for carrying out those tasks, (c) the time frame, (d) the staff resource needs, and (e) the cost share dollars needed to implement the recommended nonpoint source control practices.

Agreements
Following approval of a priority watershed plan, there is a three year period during which landowners and municipalities can sign cost share agreements for the design and installation of BMPs. Installation of BMPs must take place within five years of the date the cost share agreement is signed. The BMPs must be maintained for 10 to 20 years. Failure to do so is a breach of contract and requires repayment of the cost share funds received.

Summary

This review suggests that there is both technology and information available to develop a voluntary and targeted GSP that is dedicated to improving environmental quality as it relates to agriculture. However, the elements of such a program are complex and require understanding of both the data on the location, type and magnitude of the problem as well as the diverse motivations of the nation's agricultural producers. However, the producers involved in a GSP oriented to environmental improvement may not be the same producers currently participating in agricultural commodity programs.

This review further suggests that elements of a successful, voluntary GSP include (a) targeting to priority areas and farms within these areas, (b) tailored and targeted educational programs, (c) whole farm system planning, (e) emphasis on information gathering and use, (f) producer involvement in the design and implementation of the program and plan, (g) transitional cost-sharing for some practices and longer term cost sharing for other practices as part of a system, and (h) an explicit or implicit threat of future mandatory programs should voluntary programs fail to achieve public goals.

What is clear is that improvement of nonpoint pollution will require changing the way we have approached the problem in the past. We know enough to do better, to be more cost effective, and for many farms, still preserve the profitability of farming.

At the same time, we should be realistic about how much a targeted, voluntary GSP program can reasonably be expected to accomplish. Etzioni (1994) in an editorial on social programs makes some comments equally germane to conservation programs:

> On one level, both from personal experience and from numerous studies, we know that it is extraordinary difficult to change habits, personality traits, culture, and social institutions.... Let us...dedicate our efforts to effective but clearly delineated projects... This humbler approach is likely to have a very attractive side effect: it may enhance public willingness to pay for such projects and may also restore public trust in our leaders and institutions (pp.15-16).

Still, we know enough to improve the design of conservation programs, and improved information will be forthcoming that will allow even further refinement of such programs. Whether a voluntary GSP program will reach its full potential will depend on both creativity in using such information and public resolve to implement the program as designed (Hoban, 1990).

Footnotes

[1]While there are differing advantages and disadvantages that come with using different whole-farm-plan providers, I will not address these issues in this paper. For a discussion of some of these issues see Wolf and Nowak (1994).

[2]A farming system analysis "comprises the pattern and sequence of crops in space and time, the management decisions regarding the inputs and production practices that are used, the management skills, education, and objectives of the producer, the quality of the soil and water, and the nature of the landscape and ecosystem within which agricultural production occurs" (National Research Council, 1993, pp 106-107).

[3]If the most profits and the most environmental protection possible is to obtained from an agricultural system, a producer must not only be informed about the relationships between agricultural and environmental systems but also possess good management skills. The careful use of this information in farming has been referred to as "high precision farming" (Munson and Runge, 1990). Such high precision farming can include alternative agricultural practices within the farm system.

[4]Similar recommendations have been made in other studies. See the Office of Technology and Assessment (US Congress, 1990) or the Journal of Soil and Water Conservation special supplement to the March-April 1994 issue. This supplement was entirely devoted to nutrient management.

[5]As Dobbs (1994) notes, however, an important factor to consider is whether a producer is adopting an alternative practice such as a changed tillage method or whether a whole farm system is being adopted that changes crop rotations and the relationships between crops and livestock by, say, making livestock rations more forage-based. Dobbs predicts from his research that whole system changes to more "sustainable" farming systems would result in some decrease in profits, at the present time, in high-output regions such as the Corn Belt. However, this conclusion is specific to this argo-climatic region and sustainable systems appear more competitive in predominately small-grain areas than in the Corn Belt.

[6]Uncertainty surrounding the ultimate impact of adoption of different farming systems and technology is an important barrier to participation in a GSP. More research is needed on the marginal economic impacts of alternative conservation systems. What is known needs to be better disseminated to producers. See Fletcher and Seitz (1986) for a detailed discussion of information needs for conservation decisions from a producer's perspective.

[7]However, property tax credits, like all permanent financial entitlements, will be eventually capitalized into the value of land, thus eventually reducing the intended incentive.

[8]Abbreviated from Office of Technology Assessment Report, *Beneath the Bottom Line*, (1990), pp. 189-191.

[9]For an interesting discussion on compliance see Esseks and Kraft (1993). Their research on midwestern producers suggests that producers are more likely to expect detection when they are not in compliance if they have relatively frequent contact with the local USDA offices and if they also believe that monitoring makes use of aerial photography.

[10]Abbreviated from John G. Konrad, James G. Baumann, and Susan E. Bergquist, (1985).

Implementation Issues for Alternative Green Support Programs

By Jerry R. Skees

Policy makers are being confronted with questions about how to address some of the environmental problems caused by agricultural production. Anyone who strives to help with this charge will recognize both the importance of such efforts and the challenge. It is simplistic to state that government involvement is warranted. The challenge is to determine what type of government involvement will provide the most good for society. One policy option currently being considered is providing farmers positive incentives to adopt environmentally friendly practices through some kind of green support program (GSP).

While GSPs are quite attractive in principle, it will be the detail of their design and the attention given to implementation that will determine the success of such an approach. This paper examines important implementation issues surrounding alternative designs of a GSP. A focus of this paper will be on potential implementation problems stemming, in part, from the political economy within which a GSP will be designed and administered. Many of the problems raised in the paper can help improve the design of a GSP, including the type of legislative authority needed for effective implementation. However, other problems raised can only be addressed by those responsible for implementing any future GSP. It will take a collective and concerted effort to address the problems raised in this paper. But this is the task that must be undertaken by those who wish to design a successful GSP.

What is the Problem?

There are many agro-environmental problems that merit emphasis; soil erosion, pollution of surface waters, ground water contamination, wetland conversion, damage to wildlife habitat, over use of pesticides and fertilizers, pesticides in the food supply, etc. Pollution caused by agriculture is generally referred to as non-point source pollution because it is difficult to trace the source of the problem back to a specific farm or field. These types of environmental problems have been classified as market failure. The market provides farmers insufficient economic incentives to modify behavior and reduce the environmental problems present in the U.S. farming system.

If society is willing to compensate farmers for the transaction cost or lost income of switching to more environmentally sound farming practices, it may be possible to make

Jerry R. Skees is a Professor in the Department of Agricultural Economics, University of Kentucky.
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both farmers and society better off. In principle, such compensation should just equal the marginal benefits of the improved environment. If we could measure the benefits of reducing the negative environmental consequences of our farming systems and if we knew how much members of society were willing to pay, we would know how much to invest in a GSP. Since we do not know these values and since we have no market institutions to provide the direct transfers, we must rely on the political process to decide how to invest in a GSP.

Designing and Implementing a GSP: Consideration of the Political Economy

A logical response for dealing with a market shortcoming, like the externalities associated with our farming systems, is to turn to government. This section lays a foundation for understanding some of the implications of relying on government interventions to deal with the agro-environmental problems associated with conventional agricultural production. Understanding the political economy within which public policy is forged, helps us to understand the motivation and behavior of participants in that process (Bartlett, 1973; Simon, 1949; Lindblom, 1968; Wolf, 1968; Buchanan, 1972; and Mitchell, 1990). This in turn provides important insights that can help improve policy design.

Since a GSP would provide new benefits or change the distribution of existing farm program benefits, many groups will be interested in the details of how a GSP is designed and implemented. These groups can be divided into four general categories: (1) elected officials; (2) bureaucrats; (3) farmers and (4) special interest groups. Each of these categories of "actors," is motivated by different interests. Some will have a genuine interest in doing the "right" thing, as they see it, for the broader society. Others will be motivated by their own self-interest, as they define it. Further, each of these actors will have different information and perceptions about the farming systems in place, the degree to which they are causing any environmental problems, and the feasibility and profitability of alternative systems. As a result, each actor potentially will have a different vision of what a GSP should be. Such asymmetry in perception, information and vision represents a significant, though hopefully not insurmountable, hurdle to effective government intervention.

Behavior of Elected Officials

Regardless of their dedication to public service, all elected officials must be re-elected if they are to be successful. There are important implications associated with this behavioral motivation: (1) the short-run dominates; (2) elected officials have multiple and perhaps conflicting societal goals; (3) elected officials will rarely be willing to reveal their societal goals; and (4) elected officials will rely on information from constituents and interest groups when making decisions.

Since most elected officials are faced with an impending election, the performance they want from a policy will typically focus on short run results, often at the expense of long-run achievements. This means a GSP must have some short-run goals and benefits that are achievable to placate the political system. However, many of the environmental benefits that would be generated by a GSP are achievable only in the long run. For example, some agricultural chemicals that are present in our water systems will take more than ten years to dissipate even if farmers ceased using these chemicals now. On-going support by an elected official for a GSP, to a certain extent, will be contingent upon the perceptions of the electorate about the potential success of such a program. This underscores the importance to elected officials of including some short-run, achievable goals that can be used to motivate constituents to support a GSP, even if they interfere with the achievement of important long-run goals.

Elected officials will have multiple and perhaps contradictory performance goals. This is a natural outcome of consensus building among competing interests. Elected officials rarely reveal their performance goals—even if they have a well developed set of performance criteria. Thus, a GSP probably will be motivated by a variety of objectives. The conflict between those who want to protect the environment and those who want to protect access by farmers to taxpayer transfers may represent the most serious difference in objectives. Since elected officials must build a consensus around conflicting interests this increases the probability that mixed messages will emerge from any GSP legislation.

Although it may be true that elected officials turn to interest groups for information in the interest of getting re-elected, this is too simple. Elected officials are bombarded with information. We are all bounded in terms of how much we can absorb — elected officials are no different. Information overload increases the search costs and limits the ability of elected officials to seek out new or different sources of information. It is natural that policy-makers will default to naive criteria or use subsidized information that is often supplied by rent-seekers (rent-seeking refers to the motivation for individuals who profit from existing or new rules of government that redistribute property rights to lobby for that purpose). All of this can increase the power of those with the most to gain from individual policy decisions and who are motivated and positioned to focus attention on selected bits of information.

Returning to the theme of rent-seeking behavior provides a basis for understanding why those with the most to gain from a policy change will be willing to invest the most in providing subsidized information in the process. Many decisions in the policy process are made, not with scientific information, but with anecdotal information. Personal testimony by citizens who are brought to Washington by an interest group can make a difference. Making policy based on such information begs the question about how generalizable the testimony may be or even whether it is objectively valid. While it is important to learn from such cases, it may be quite damaging to develop national policy using this type of information.

Bureaucratic Behavior

While many factors influence the behavior of bureaucrats, one which is of particular importance in this discussion, is how concern about job security influences program implementation. Being concerned with job security is not necessarily bad. With the proper tension and reward structure, concern for job security can be quite positive. Job security concerns present the potential to change the time frame — allowing more time for an evaluation of the GSP as the bureaucrats administering a GSP must think through both short and long-run consequences of their decisions. On the other hand, concern for job security can result in agencies seeking to service powerful clientele and protect increasing budgets regardless of the impact on stated objectives.

The performance objectives of the government agency(ies) implementing a GSP will likely come from a mixture of those established via legislation and the influence of those whose well-being depends on how implementation occurs. Again, short-run performance may dominate the thinking of those being asked to participate in a GSP — the farmers. A key to gaining farmers' voluntary participation in a GSP will be to capitalize on issues where long-run performance will dominate the farmers thinking. This will involve mixing the legislative objectives of a GSP with what is important to farmers. For example, farmers understand that their wealth depends on the long-run value of their farms. Soil erosion will reduce that value. Farmers are also learning that any environmental hazard (e.g., buried fuel tanks) will reduce that value. Further, farmers are concerned about ground water quality since their families generally consume the ground water that may be contaminated by their farming practices. The greater the disparity between the objectives mandated by Congress and the concerns of those expected to participate in a GSP, the harder it is for an agency to successfully implement a voluntary program.

One way for an agency to build political support is to provide GS payments to as many people as possible while also minimizing the transaction cost of the recipients. This combination of incentives could jeopardize the effectiveness of any GSP if targeting and performance standards are compromised. The degree to which the implementing agency gives flexibility without accountability to the local bureaucrats will, in large part, decide how serious this problem becomes.

While it is necessary to give implementing agencies flexibility in administering new policies, such flexibility can result in a program that fails to meet the objectives of the policy makers. This failure may simply be due to unrealistic expectations (unreachable goals, mixed signals, and/or insufficient resources) from the policy makers, or it may be due to more fundamental problems within the implementing agency. Wolf (1994) identifies three behavioral patterns for bureaucracies that can be the source of more fundamental problems: (1) budget growth; (2) technological advance; and (3) information acquisition and control.

Since it will be difficult to develop reliable measures of performance for a GSP, given the non-point nature of agro-environmental pollution, a natural tendency will develop to search for alternative performance measures. Given the complexity of tracking changes in environmental pollution at the farm level, the implementing agency could default to budget growth and/or the number of people within the implementing agency as measures of performance. Managers of large bureaucracies, both in the public and private sector, are sometimes rewarded based on the budget they control and/or the number of people they oversee. These types of internal objectives are easy to measure and do reflect a degree of expertise and skill on the part of managers. However, they may have little to do with achieving the intended objectives of a GSP.

Another tendency within large bureaucracies is to build complexity into the system. This can be simply because of the lure of advanced technologies or it can be motivated by the job security objective. A fine balance is necessary since investments in technically trained people and information systems will be essential for an effective GSP. A further complication is that even appropriate investments may take several years before showing how they contribute to improving the environment.

Once a GSP is in place different interests will have opportunities to gain from the change in property rights. These changes must be anticipated so that implementing agencies will know who stands to gain or lose from the rules that are established. As bureaucrats seek to maximize job security they may turn to the most powerful clientele in order to secure their political base of support. If that client is the farmer (whose behavior they are attempting to modify through incentive payments) it could present a potential conflict.

Among the most serious concerns for a GSP is the extent to which the implementing agency is close to those whose behavior they must, to some extent, monitor and evaluate. This is a classic problem. Several years ago it became apparent that some USDA meat inspectors were too cozy with managers of plants under their jurisdiction. The new policy adopted by administrators in USDA was to move the inspectors to different territories every two years so that they would not become too comfortable with plant managers. Some of the same concerns have been raised about the implementation of the conservation compliance provisions of the 1985 Food Security Act. In this case, questions have been raised about how farm plans have been developed and about whether the farm plans are consistent with Congressional intent (Cook and Art, 1993).

Each of the behavioral patterns by bureaucrats discussed above increases the importance of the incentives within the implementing agency. Incentives in government are very different than those in the private sector. What is needed is a system that rewards those in the implementing agency based on demonstrated improvements in the environment rather than alternative measures of performance. This would help improve accountability and could offset some problems discussed here.

Farmer Behavior

Although many factors influence farmer behavior (Batie, 1994), optimizing profits and/or wealth is a dominate behavioral objective. Understanding the time path associated with modifying existing farming systems or adopting new technologies and practices will be essential. Heimlich identifies four classes of operation that match different time paths of farmers: (1) a net gainer system where the new practices result in higher income in both the short and long run; (2) a longer-term gainer system where there are large initial costs that keep profits down in the early years, but the investment will yield more profits than the existing system in future years; (3) a slight looser system with slightly lower returns both in the short and long-run; and (4) a clear looser system with significantly lower returns in the short and long-run. Each of these categories requires a different type of educational program, technical support, incentive (payments or cost-share) and duration of payment.

Under the net gain system, educational programs should be sufficient to motivate modified farmer behavior. Under the longer-term system an initial government subsidy may be required to encourage investment, but there is little justification for continued support once the new system becomes profitable. The slight looser system would require a continued public investment to entice the farmer to stay with the new farming system. The clear looser system may be too expensive for a GSP — justifying government regulations to modify farmer behavior.

Providing monetary incentives through a GSP payment should change the behavior of some farmers. However, a subset of farmers will seek increased rents from the GSP. They have two ways in which to accomplish this: first by supplying subsidized information to influence the rules and second via the information edge that they have regarding what actually transpires in their farming operation (information asymmetry). As an example, in the case of the former, there is an incentive for the farmer to convince policy makers (both elected officials and bureaucrats) that most of the systems being discussed are slight looser systems that require on-going GS payments. An example of the latter is that as farming systems are changed, farmers will know more than any of the other actors about the profitability of the new systems. The implementing agency may decide that a new farming system is a slight loser (requiring on-going GS payments) while the farmer finds that it is a longer-term gainer system. Many farmers would not share this information with the agency (i.e., "I don't want your money any more").

A more serious implementation hurdle is the simple fact that the farmer will always know more about what is being done on the farm than anyone else. This asymmetry in information provides the opportunity for abuse. It makes it difficult to enforce agreements that may be reached about required farming system changes. Further, it is expensive to monitor farmers to decide if they are farming properly. Farming is a very dynamic activity. Weather events and timing are critical to successful farming. Even the well-meaning farmer who has every intention of keeping his/her GSP agreement may find that they must deviate from the agreement to adjust to an unforeseen condition (e.g., a new pest or an unusually wet early season).

Interest Group Behavior

A wide variety of special interest groups will be intently interested in influencing the design and implementation of a GSP. The spectrum of interests will run from those opposed to any change in the existing distribution of farm program benefits to those in favor of imposing strict environmental controls. Some of the special interests groups involved include commodity associations, farmer organizations, natural resource conservation groups, consumer organizations, wildlife preservation groups and groups promoting sustainable agriculture, to name just a few.

The interests of these groups cover a wide spectrum of concerns. Attempting to characterize either the motivation or objectives of each of these groups is difficult. Even between allies, there are conflicts over objectives, priorities, strategies and timetables. One thing they have in common is that in order to support their particular position these special interest groups will attempt to supply subsidized information to both elected officials and bureaucrats. However, all groups are not equally endowed with financial resources, ability to communicate information, and degree of access to decision makers.

It can also happen that individuals associated with special interest groups have made careers of being activists. Thus, they may have an interest in expanding their influence as part of their rent-seeking activity. A strong commitment to a cause can limit willingness to compromise and result in extreme positions. All these factors can make finding common ground between diverse interest groups difficult.

Understanding what motivates each of the four groups identified above is important for implementation of an effective GSP. The important lesson is that much of the political economy runs on rent-seeking, job security, and vote maximization behavior. Each of these activities is economically inefficient and each can ultimately lead to shortcomings in government policy. Building the proper tension in the system to take advantage of what motivates each of the actors will be a key to a successful GSP.

Basic Elements of a GSP

It is useful to attempt to define the basic elements of a GSP. A GSP would be a voluntary program that provides monetary incentives to farmers to modify their behavior by incorporating into their production practices more environmentally sound farming systems and practices. An important element in the design of a GSP must be an appreciation for the diversity of farming in the U.S. Farming systems are influenced by different soils, climates, institutions, land tenure patterns, and people. The highly localized manifestation and intensity of specific environmental problem(s) as well as the appropriate sustainable response (alternative farming system, practices and/or land use) mandates that a GSP be flexible enough to account for these important differences.

Recognition of this diversity in farming systems weighs heavy in support of a decentralized system for implementation of a GSP. A decentralized system would focus on local eco-systems and provide adjustments for local conditions. Local authority should be involved in deciding both definitions and priorities of environmental problems. This may mean that in some areas improved practices to reduce soil erosion dominate while in others reducing the use of a herbicide that is appearing in the local water supply merits more attention.

To the extent possible, the local agency should base monetary incentives on a standard of performance that is easily measurable. This will likely require a contract between the individual land user and the implementing agency (similar perhaps, to the conservation compliance plans used by the SCS). This contract needs to be clear in terms of what is feasible and the performance timetable. Only when the terms are met, would a complete monetary transfer be made.

Experience with the conservation compliance plans illustrates the potential difficulties associated with this type of contract. First, working with targeted farmers to develop conservation plans represents a major commitment of personnel time. Second, it is difficult to establish uniform contracts given the diversity of farming systems and agro-ecological conditions found throughout the U.S. Third, it is impossible to check all land users to decide if they are in compliance with their contracts. Fourth, many farmers find this type of contract objectionable as it infringes on their right to farm as they see fit. The fourth problem highlights the importance of flexibility — land users should have flexibility to renegotiate their contract as agricultural technology or economic conditions change.

The requirements of a GSP contract could come from either the identification of a specific set of practices for each farm type using technology based standards, or the development of a tailored site-specific planning process. The driving force for both approaches must be a set of identified environmental quality goals. The Committee on Long-Range Soil and Water Conservation favors use of a tailored site-specific planning process. A five-step process is envisioned:

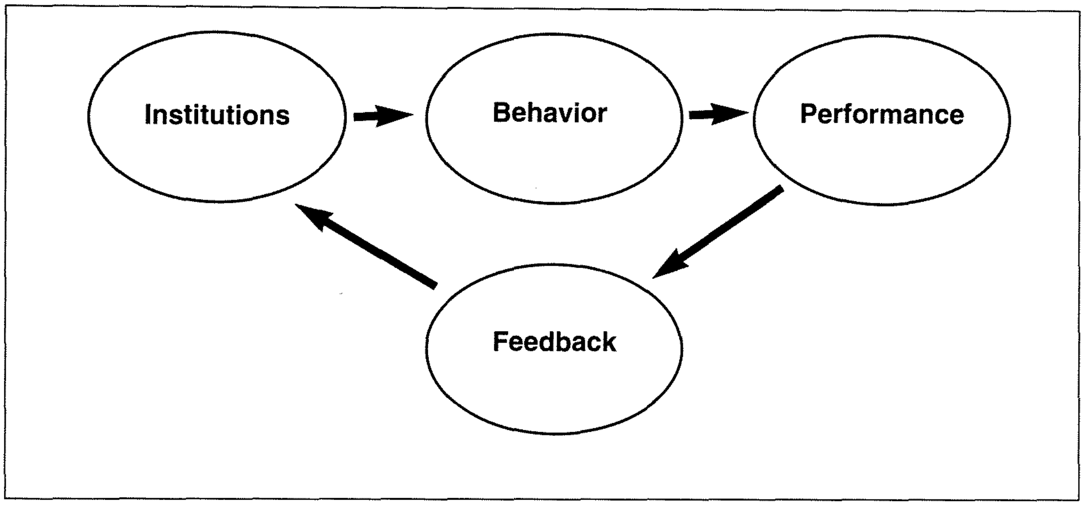
1) identifying and ranking environmental quality goals (setting the performance standards),
2) developing an implementation strategy that outlines the process of achieving those goals,
3) delivering the needed technical assistance to farmers as they implement a farm plan that is consistent with one and two above,
4) monitoring compliance to ensure that farmers implement their plans and that the desired outcome is achieved, and
5) awarding the GSP to farmers who are in compliance and making adjustments via the feedback mechanisms to improve the process.

Can one agency perform all five functions? A nagging question emerges when one understands the limitations of local involvement and compliance. Can the same agency that delivers a service also serve as a regulator?

Linking Objectives with Performance Goals

While the mandate for a GSP will come from the political arena there are two possible conjunctions where stated objectives may be developed; the Congress or the implementing agency. Congress is likely to provide mixed signals as a result of the consensus process used to develop support for a GSP from a diverse set of interests. Thus, an early challenge for the implementing agency will be attempting to give the general and mixed objectives from the legislative process a clear operational definition. Understanding what is achievable requires a considerable understanding of current farming systems and the potential benefits of alternative systems.

There are many different visions of what can be achieved with a GSP. An agency responsible for implementing a program with many mixed objectives will soon discover that while it may make some people happy some of the time — it is impossible to make all of the people happy all of the time. Congressional intervention will add to the complexity via both formal and informal channels. Farmers who feel that they have been treated badly may use their member of Congress to place pressure on the implementing agency. Likewise an environmental group that feels the GSP is not working will use Congress to pressure the implementing agency. These political realities increase the importance of stated objectives and achievable goals. Stated objectives can serve to focus the implementing agency. It is important to develop performance objectives and a feedback process to decide if the objectives are being met.



Accountability in the system will be lacking without appropriate feedback mechanisms to learn if stated objectives are being met. Batie (1994) emphasizes the importance of understanding why farmers don't farm in more sustainable ways. This understanding should help in designing incentives to get farmers to adopt new practices. The feedback loop should be focused on methods to change the incentives of the institutions involved as well as the farmers. For example, if it is learned that the institutional reward structure is rewarding bureaucrats in a way that is inconsistent with the performance goals, a different reward systems may be needed.

There will be a natural tendency to measure performance as the number of farms adopting improved farm plans or investments made in animal waste facilities. In the short-run this type of criterion is reasonable. However, the feedback loop must include some additional measures of performance — are the investments making any difference in the environment? This interactive learning and adjustment process is essential for effective program implementation.

The Role of Science, Technology, and Information

Science, technology and good information systems are essential to the successful implementation of a GSP. Referring back to the five step process identified by the Committee on Long-Range Soil and Water Conservation, reinforces the role of science, technology, and information in developing the implementation strategy, delivering the technical assistance, and monitoring for compliance. Additionally, science will be relied upon to determine if improvements are being made in the environment and as the source to create and identify new environmentally friendly practices and technologies.

A key to successful implementation of most government programs is information. It is easy to anticipate that there will be asymmetry in information when it comes to implementation of most conceivable GSPs. No one will know more about what goes on with the farming operation than the farmer. This imbalance of information will enhance the rent-seeking opportunities of farmers resulting in potentially serious inefficiencies and possibly a failure in implementation. Since farmers will know more about their farming activities than the implementing agency, this opens the door for abuse and unintended consequences.

Attempts to balance the information can be expensive and can lead to large bureaucracies. Funds used by an agency(s) administering a GSP to obtain more information about activities on the farm could siphon funds away from GS payments. This phenomenon has been called "the leaky bucket." The challenge for a GSP will be to design a program that minimizes the leaky bucket problem while also minimizing the asymmetric information problem. In principle, the marginal investment in the information system for an implementing agency should just equal the marginal benefits associated with how well that information reduces abuse of the GSP and helps farmers in developing new farming systems to improve the environment.

The gaps in our knowledge about agro-environmental problems can be daunting. In many cases more is unknown than known about the impacts of different farming systems on the environment. National data bases on agronomic practices are rare. Attempts to link the varied data sources that do exist are also limited (see Heimlich's paper for an exception). In addition, there are a limited number of digitized soil maps that can be used with geographical information systems. SCS has worked extensively with models on erosion (EPIC) and has begun work on models used to evaluate herbicide and pesticide uses. Some data also exist within the state Agricultural Experiment Stations.

While there is much to be learned about the relationship between agriculture and the environment, a major theme of the book *Soil and Water Quality: An Agenda for Agriculture* is that improved use of what we do know holds significant promise. What is exciting about using more of what we already know is that it can lead to both a more profitable farming sector and improvements in the environment. In some cases communication of information is a major barrier prohibiting farmers from adopting these proven alternatives (Batie, 1994).

Research and development of more sustainable technologies, practices and plant materials designed to give farmers more options is also important. Some have argued that the culture within the Land Grant Universities has been resistent to the development of more sustainable technologies. While these critics have some legitimate concerns, significant activity has occurred with the land grant system. For example, the land grant system is largely responsible for development, refinement, and dissemination of technologies associated with reduced tillage systems. Similar efforts are needed in the arena of chemical use. Lockeretz and Anderson have made a strong case for developing a new research agenda. Despite concerns about the responsiveness of the land grant system, there are few institutions that can compete with their elaborate structure. The land grant model which incorporates both development and dissemination (via extension) is precisely what is needed for new-sustainable technologies.

There is a need for new technologies that will result in improved monitoring of the environmental problems associated with farming. Such technologies hold promise for contributing to the effective implementation of a GSP. New computerized monitoring systems allow immediate testing of nitrites in ground water. In addition, linking digitized soil maps with the field position of farm equipment now make it possible to optimize the application rates of chemicals based on differences in soils. These technologies can also be used to optimize tillage and residue levels.

In the context of farm support programs, science can help increase the awareness that many of these programs may have had the unintended consequence of contributing to erosion and environmental problems (Reichelderfer, 1990). Reform of price and income support programs and disaster payments, a call repeatedly heard these days, may alter farming practices in such a fashion that would lead to improvements in the environment. Farmers who have grown only one or two program crops at the extensive margin may find, that without the same level of support, they would be growing different crops that are less erosive and require fewer chemicals.

A major caution in designing a GSP should be an awareness of the dynamic nature of agriculture. It is possible that a GSP could be targeted to a region based on current cropping patterns. The benefits of the GSP could result in a continuation of these patterns even when reform of farm policy possibly would have led to a new and less erosive crop pattern. For example, if government support for cotton growers was reduced in the high plains of Texas, growers may return to livestock production and grassland. A GSP targeted to the high plains cotton farmers for payments to reduce use of a problem chemical, may prevent this type of adjustment.

Federal Versus State Level Control

Questions of Federal versus state level control of a GSP merit attention. While it is true that Federal control will provide for more uniform administration of a GSP, there are significant differences in the environmental problems that raise serious questions about use of a Federal standard without some local control. For example, addressing environmental problems such as the ground water problem at a local level has merit. One approach would be to give states the flexibility to design and administer their own GSP. However, there are also advantages to having a federal agency administer a program that is decentralized and allows local flexibility in problem definition and solution. Different policies in different states would be ignoring the fact that most environmental problems do not respect state boundaries. Inconsistent polices in neighboring states could be disruptive to interstate commerce.

Providing states with complete control would likely result in less uniformity in a GSP. Many states have been more proactive than the Federal government in developing agro-environmental initiatives. Some of this activity has been innovative and has served as a model for Federal involvement. In Pippin county, Wisconsin there has been a successful pilot program that provides a property tax credit for farmers who use improved farm plans designed to reduce soil erosion. Although, not a GSP, the state of Iowa has passed a set of bills to protect groundwater from farm chemicals. The Iowa legislature passed a 75 cents-per-ton tax on fertilizers to be used to fund research, monitoring, licensing, and inspection. They also allocated $1.5 million for a sustainable agriculture center at Iowa State University. By contrast, Connecticut has passed a law that makes farmers liable for any groundwater contamination.

While states have taken some action, allowing for local determination of priorities and standards should facilitate improved commitment at the local level. This would improve the chances of effective compliance and a greater level of participation and cooperation by farmers. On the other hand, if farmers feel that they have no control over setting priorities and standards they will be less likely to participate. Under these circumstances more money would be needed to provide incentives to participate.

In reality the choice of either federal or state control is not as simple as either state or federal control. A federal policy with well-developed guidelines, implemented through a federal agency working in concert with state agencies, may represent the most reasonable approach. This approach has been pursued by the EPA in implementation of the Costal Zone Act which was passed to reduce sources of non-point pollution in coastal waters (EPA Guidance Specifying Management Measures for Sources of Nonpoint Pollution In Coastal Waters, 1993).

Alternative Agencies for a GSP

On the national level, three possible agencies that could be called on to implement or participate in a GSP include: the Agricultural Stabilization and Conservation Service (ASCS); the Soil Conservation Service (SCS); and the Environmental Protection Agency (EPA). Turning to the SCS or the ASCS favors a decentralized approach while use of the EPA would represent a more centralized approach. There are some obvious trade-offs associated with use of any one of these agencies.

Should a GSP be used as a supplement or replacement for current price and income support programs, a natural tendency would be to turn to the ASCS to administer the GSP. A major strength of the ASCS is well-established and decentralized field offices and personnel. This makes the ASCS a powerful organization at the grass-roots level.

However, the overlap between regions receiving most price and income support payments and regions with the highest potential for a variety of agro-environmental problems is somewhat limited (Heimlich, 1994b). Thus, if environmental objectives dominate the design of a GSP, some restructuring of the ASCS field staff might be necessary. Further, field staff for the ASCS have a mixed history of being able or willing to impose sanctions on farmers. It is easy to understand why this has been a problem since the structure of local ASCS committees is made up of farmers and landowners. It is difficult to tell your neighbors and friends that they are not in compliance with a government program. These local committees also build their power by distributing benefits. Another potential barrier to using the ASCS as the implementing agency is due to the institutional culture within the ASCS that is grounded in helping farmers benefit from federal farm programs.

The SCS has had some experience with GS-type programs, most notably the Conservation Reserve Program (CRP). The SCS also has a well-established and decentralized field staff. Additionally, the SCS has the edge on the information systems needed for implementation of alternative farming systems and practices. Still, the SCS has had problems in adjusting from an agency that only provided technical assistance and incentives to farmers to an agency that is now expected to enforce conservation compliance.

The response of the SCS to the Conservation Compliance provisions of the 1985 Farm Bill is illustrative of the potential problems associated with allowing the SCS to implement a GSP. Admittedly, the charge passed on to the SCS was massive — develop conservation plans for all farmers of highly erodible land who are eligible for program payments. Some would judge the SCS performance in this effort as good given very limited resources. Even the Center for Resource Economics has given the SCS some praise: "Without question, conservation compliance is resulting in significant erosion control efforts on the part of many thousands of farmers nationwide" (Cook and Art, 1993). However, they have also used the USDA's Office of Inspector General's 1991 audit to criticize the implementation effort. The audit found 10 percent of the sample out of compliance and a large percentage of the conservation plans did not meet SCS technical requirements. Again, many of these shortcomings may have been due to inadequate resources. However some problems may have also been due to inappropriate incentives or the institutional culture that created a lax attitude about forcing farmers into compliance.

On the positive side, the SCS has succeeded in getting farm plans developed for a large number of farm operations in a short period. The fact that the SCS has 90 percent of eligible farmers in compliance with the requirement to develop farm plans is significant. However, the real test is not in the development of the plans which farmers have until 1995 to complete, but in the implementation of the plans which will begin in 1995. Thus, the actual effectiveness of SCS in enforcement is yet to be determined.

In visits with SCS personnel, I was told that much of the culture within the SCS was related to age of the local SCS personnel. It was their impression that older personnel were more likely to find the adjustment to a regulatory agency more difficult and younger personnel (who lacked the institutional experience of earlier years) were more likely to carry out the regulatory requirements. I further learned that SCS field staff have had significant turnover in the past ten years. This suggests that many types of problems discovered by the OIG audit may be less serious in the future as new professional staff replace those with the old institutional culture.

Having the Environmental Protection Agency as the responsible agency for a GSP could provide more opportunity for compliance and enforcement of farm contracts. The EPA has significant precedence for administering a Federal program via state agencies. However, farmers would strongly object. Obviously, the EPA would be viewed with a considerable degree of suspicion by farmers. Allowing the EPA to administer the GSP would be tantamount to declaring war for many farmers. In addition, the EPA's institutional culture is significantly different than USDA agencies. EPA personnel or their counterparts in the states would be more likely to enforce the requirements that accompany a GSP contract. The EPA also has a different paradigm for evaluation of environmental problems than the paradigm within the USDA. Under the

EPA there would very likely be a greater emphasis on levels of risk. Finally it is questionable whether the EPA and the sister state agencies have sufficient resources and training to effectively implement a GSP. New resources would be needed. A GSP agency needs local involvement and knowledge of the existing farming systems — the EPA lacks such knowledge.

Of particular importance to those considering where to place the responsibility for implementing a GSP is the on-going restructuring of the USDA. Centralized service to farmers is being planned with the consolidation of several USDA agencies into one agency — The Consolidated Farm Service Agency (CFSA). The FSA would have the ASCS, the Farmers Home administration, the Federal Crop Insurance Corporation, and several other agencies together. The advantage of merging several agencies is that it would consolidate information for each farm into one agency. At present, information about farmer participation in the many government programs resides in many different places. This presents many opportunities for confusion and a barrier to potentially useful information about the farm operation. Further, it increases the transaction cost for the farmer who must complete a number of forms that require the same information.

The CFSA may offer opportunities to reduce the administrative cost for a GSP. However, the agency that is conspicuously absent from the CFSA is the Soil Conservation Service. Under the current plan, the SCS will be separate from the CFSA and will become part of the Agricultural Natural Resource Agency. It is unclear whether local USDA offices in the future will house all agencies, including the Natural Resource Agency. The USDA is also creating a system of shared information between the CFSA and the SCS.

Conclusions

Attention to the potential problems of implementation addressed in this paper will be needed if a GSP is to be successful. For some environmental problems, the constraints on effective implementation of a GSP are more serious than for others. An implementing agency must be practical and provide defined objectives and measurable performance criteria. Some kind of targeting will be essential in order for the program to achieve environmental improvements and operate within a budget.

The politics of trying to do something for too many farmers may be the single most important risk to guard against in implementing a successful GSP. In visits with several ASCS personnel involved in implementing the Agricultural Conservation Program, I heard repeated frequently that — "so many farmers have access to ACP it is questionable whether we are doing any good." Many types of environmental problems that a GSP could address may be concentrated in specific regions (or watersheds). Limited funds should be targeted to specific priority problems if measurable results are to be obtained.

Guarding against some behavioral responses from bureaucrats is important for effective implementation of a GSP. A natural tendency will be to measure performance based on activity or investments made in developing a GSP. This may have little to do with the degree to which the GSP is improving the environment. Once again, the focus on measurable performance goals will be critical for assessing the effectiveness of a GSP. This is where a well-developed feedback process will be needed.

Some farmers will have a tendency to give the impression that GSPs are the only way in which they can be persuaded to farm differently. This may occur even when the farmers learn that the new way of farming is more profitable. Those responsible for implementation must understand this and guard against this behavior. It will be difficult to learn when the GSP is no longer necessary. To the extent possible, the feedback process must provide this type of information. The system must be flexible and able to incorporate new information as our knowledge of agriculture's impact on the environment evolves. Monitoring changes associated with different farming systems will be important. The local nature of the problem mandates that the information systems and the required feedback loops to solve emerging problems be dominated by local input and administrative activity. However, the problems associated with local influence and uneven implementation also mandate that the compliance and standards be developed at the national level.

Designing institutions that will provide national standards with local input and administrative activity will be challenging. Understanding how political economy and behavior of the participants influence the information that will enter into the system will be critical for effective evaluation and adjustments. Such a system will require well-trained and dedicated employees for effective implementation. Anticipating and providing safe guards for some of the behavioral patterns that occur in a political economy can go along way towards effective implementation.

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Henry A. Wallace Institute for Alternative Agriculture
9200 Edmonston Road, Suite 117
Greenbelt, Maryland 20770-1551
Phone: (301) 441-8777
Fax: (301) 220-0164