This is to certify that the

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The Distributional Impacts on Michigan Counties of Alternative Targeted Federal Green Support Programs

presented by

Esther Day

has been accepted towards fulfillment of the requirements for

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Sandra S. Batie
Major professor

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THE DISTRIBUTIONAL IMPACTS ON MICHIGAN COUNTIES OF ALTERNATIVE TARGETED FEDERAL GREEN SUPPORT PROGRAMS

By

Esther Day

A THESIS

Submitted to
Michigan State University
in partial fulfillment of the requirements
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1996

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ABSTRACT

THE DISTRIBUTIONAL IMPACTS ON MICHIGAN COUNTIES OF
ALTERNATIVE TARGETED FEDERAL GREEN SUPPORT PROGRAMS

By

Esther Day

This study demonstrates the effects of alternative Green Support Programs. Potential agro-environmental problem data are used to form an Environmental Vulnerability Index. The index assists in the identification of the location, magnitude, and nature of agro-environmental problems.

Different targeting alternatives are considered, including: soil erosion, surface water, groundwater, and wildlife habitat considerations. Targeting options on a county basis include: targeting based on existing Conservation Reserve Program (CRP) participants for permanent easements or conservation practices, based on existing CRP participants for adoption of Best Management Practices or for "whole farm systems," and based on potential agro-environmental problems regardless of participation in commodity programs for adoption of BMP's.

Despite the complexities and data limitations, it was demonstrated throughout this study that Green Support Programs have merit in the sense that they potentially reduce agro-environmental problems and could be designed to be cost-effective.

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Chapter 1

Agro-Environmental Problems

1.1 Agricultural Nonpoint Source Pollution

River and lake pollution in Michigan resulting from pesticide pollution in soil run-off has been an important public issue debate since at least the 1970's. Public concerns over the potential health and habitat degradation risks associated with the exposure to contaminated surface and ground water have grown. There is also concern that governmental policies do not adequately address environmental concerns.

A primary source of agricultural nonpoint pollution is the application of pesticides and fertilizers. Resources for the Future (RFF) (1993) conducted a study on agricultural nonpoint-source pollution for the Great Lakes Basin. The study found that agricultural nonpoint pollution has caused serious damage to the basin's surface water. Specifically, the Resources for the Future concluded, that inland streams and rivers on the US side of the basin have been severely affected by nonpoint-source pollution; "all but one of 297 watersheds in Michigan have been contaminated by nonpoint-source pollutants" (Hoffman, Resources for the Future in Environmental Working Group, p. 29). The data was compiled by Resources for the Future using the Census of Agriculture (1987) data and indicates that about 75 percent of all farms, or 61 percent of all cropland acres, in the Great Lakes Basin were treated with commercial fertilizers in 1987, while pesticides were applied on about 57 percent of all cropland (Hoffman, 1993, p. 28). The chemicals atrazine, atrazine degradation products, and metalochlor are the most heavily used chemicals on corn.

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used chemicals on corn, soybeans, and alfalfa. Also, they were the most frequently detected and most persistent chemicals in the environment (Hoffman, 1993, p. 28). Similar findings came from other research (Hoffman, 1993, p.1) which indicates that "agricultural nonpoint-source pollution has already caused serious damage to the Great Lakes region's surface waters, including the Lakes, inland rivers, and streams."

The US Army Corps of Engineers (1983) studied Lake Erie and the land adjacent to the lake and found that nitrogen fertilizer and pesticide residues from agricultural practices have been found extensively in ground and surface water at levels potentially dangerous to human, animal, and/or plant life. Nutrients and pesticides dissolved in run-off or attached to soil particles influence water quality such that various uses of water are altered. The most extreme consequences are eutrophication, excessive growth of algae, and rooted vegetation caused by excessive nutrient run-off.

1.2 Environmental Problems and Policy Options

As the 1995 farm bill is being discussed, many new issues are emerging regarding the impact on the environment of agricultural production. The levels of fertilizers applied; the acres of crops using high rates of pesticide application; excessive manure production from confined livestock production; erosion from lands; all are potential sources of environmental problems stemming from agricultural production.

Federal soil conservation policies and farm programs have existed for over half a century, with most major programs designed during the Great Depression. Most conservation programs have been focused on reducing soil erosion, building on the first soil erosion programs which were authorized to provide relief from the severe economic conditions of the 1930's by paying farmers to idle erosive land (Batie, 1985). Through most of the Farm Bills' history, conservation programs allowed two goals to be pursued simultaneously: the maintenance of farm income and soil conservation.

1.3 The Conservation Reserve Program

While soil erosion was still a concern starting with the 1990 farm bill, water quality issues began to emerge in the agricultural policy debate. This emphasis on nonpoint-source water quality issues stemmed from several sources. First, soil erosion issues were less urgent, due to the successes of the Conservation Reserve Program (CRP) as well as conservation compliance implemented in the 1985 farm bill (Norris and Clark, 1995). Also, point source pollution had been largely regulated and was no longer seen as pressing problem, thus, policy attention turned to environmental problems stemming from agricultural production.[1] In addition, research suggested that off-site water quality damages exceeded on-farm productivity damages by several magnitudes (Ribaudo, 1986).

The 1985 farm bill, on the other hand, responded to the public's increased concern about environmental quality with the Conservation Reserve Program (CRP), combining environmental objectives with agricultural production control. Specifically, the Conservation Reserve Program, established by the US Department of Agriculture (USDA) in 1985 as part of the Food Security Act, focused on the idling of croplands with

[1] Nonpoint source pollution is any pollution where the source of the pollutants cannot be readily identified.

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highly erodible soils in order to control damages done by agricultural production practices.[2] The 1990 Farm Bill reoriented the focus of the CRP by adding water quality as a priority concern for selecting the Conservation Reserve Program lands. Thus, the CRP, which had initially focused primarily on the soil erosion problems of the Great Plains, and was extended in 1990 to the Midwest and more eastern regions of the US.

CRP pays farmers to retire land from crop production to plant grasses or trees.[3] In order to implement the new 1990 CRP program, eligibility criteria had to be changed. "The new CRP bid acceptance process was designed to select lands offering the highest conservation and environmental benefits based on an Environmental Benefits Index (EBI), relative to the government costs of enrollment. The conservation and environmental goals embodied in the EBI were surface water quality improvement, potential ground water quality improvement, preservation of soil productivity, assistance to farmers impacted by conservation compliance, tree planting, enrollment in hydrologic unit areas and enrollment in established conservation priority areas" (Johnson, et. al, 1995).[4]

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[2]Farmers participating in USDA's voluntary crop price support program were given the option to receive rental payments to enroll their highly erodible land in a land reserve for 10 years.

[3]As the CRP contracts encompassed the current 36.4 million acres, almost $20 billion will have been spent over the full term of the contracts. The first CRP contracts, covering 2 million acres, will expire in 1995. In 1996 and 1997, contracts on more than 22 million acres will expire (Heimlich, 1994).

[4] "CRP bids were subjected to a two-phase acceptance process as follows: 1. The first phase established a bid maximum for each tract of cropland bid. 2. If a bid did not exceed the bid maximum specified for the particular tract and if the total acres to be enrolled in the bidding period were less than the acres in the eligible tracts, then CRP bids with the highest EBI relative to contract cost were accepted. Acreage limits set for

Even though the CRP to date has shown significant improvements in environmental quality, it is not clear to what extent funds will be allocated to replace the CRP program once all contracts have expired. The expiration of CRP contracts gives rise to concerns regarding loss of conservation, wildlife habitat, and other environmental benefits.[5] Additionally, the cost effectiveness of the CRP in achieving environmental quality is questionable. Thus, one aspect of the policy debate is whether a continuation of CRP, if enacted, should include a redesign of the CRP to obtain even more environmental quality benefits. Another question in the current policy debate, is whether existing commodity program participants should be required (or subsidized) to implement farm practices that alleviate agro-environmental problems (in addition to soil erosion problems) regardless of their participation in the CRP. The focus of this thesis is to address these questions and to suggest possible solutions. The hypothesis of this study is that the current Conservation Reserve Program does not reduce agro-environmental problems despite its focus on idling highly erodible land and the incorporation of water quality concerns.

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each CRP bidding period determined the lowest benefit index to cost ratios accepted" (Johnson, et al, 1995).

[5]Potential public benefits from the participation in the CRP include lower water treatment costs, lower sediment removal costs, less flood damage, and increased recreational uses (Ribaudo, 1989).

1.4 Federal Commodity Programs and Disaster Programs

Federal Commodity Programs were primarily designed to support farm income and to maintain an expanding agriculture. Existing farm programs have not been designed to encourage environmentally protecting practices, with the exception of conservation compliance provision that requires the adoption of certain farming practices on lands with highly erodible soils. In fact, agricultural and environmental policies are frequently inconsistent with one another (Reichelderfer, 1990). The reason for this inconsistency primarily lies in the fact that each set of policies has evolved separately. As Reichelderfer (1990) points out, "the institutions charged with developing and implementing agricultural policies often are not those responsible for environmental policies affecting agriculture."

Farm programs are administered by the federal government while most environmental policies are largely administered by state and local governments. Additionally, the environmental community and the agricultural community typically have different perceptions as to the role of the federal government regarding issues within their domain. As pointed out by Carriker and Abdalla (undated draft paper), the agriculture conventions emphasize voluntary compliance and incentives while the conventions in environmental matters primarily favor regulation.[6]

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[6]The price support system guarantees farmers the support price on a portion of the farm's production potential as established by set-aside requirements and past yields. The target price, another form of income support, is designed to cover only on the participating farmers' acres and on the yield per acre. The target price policy has been fixed in this manner since the 1985 farm bill. Deficiency payments based on target prices as well as Non-Recourse Loans were essentially designed to support farm income. These programs are based on the average yield per acre of a certain crop and the number of "base" acres on a given farm. The primary consequence of this policy has been to encourage farmers

In order to qualify for commodity payments, farmers have to comply with acreage set-aside. The federal acreage reduction program is designed to reduce federal budget expenditures and the reduction of crop surpluses. The Acreage Reduction Program has primarily been targeted towards production control, "implying a preference for higher output lands and thus lower pollution-to-output lands" (Runge, 1994). This policy does not significantly improve environmental conditions, however, because farmers generally retire their lowest productivity acres, which may or may not be the land with the highest environmental vulnerability. Additionally, Heimlich and Osborne (1993) have established that the acreage reduction program has failed to established a vegetative cover sufficient to prevent adverse environmental impacts such as soil erosion. They found that acres enrolled in the acreage reduction program are constantly shifted from one location to another, failing to provide a consistent impact on soil erosion prevention or, for that matter, wildlife habitat provision.

Federal Commodity Programs are not inclusive of all crops and livestock. Rather, the coverage of price support programs have been limited by Congress to commodities which were designated as "basic" for the competitiveness and maintenance of the US agriculture. Currently, the commodities covered, on some part of the program, include

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to grow program supported crops in order to retain the "base". Additionally, farmers have been encouraged to increase yields, resulting in higher irrigation and, therefore, higher groundwater depletion and higher soil erosion. Increased use of fertilizer to obtain a higher yield can result in an increased level of soil and groundwater contamination. Furthermore, crop rotation as a management practice is discouraged, especially when support prices are high. All components of federal commodity programs will be discussed in Appendix D.

wheat, rice, feed grains, cotton, milk, soybeans, and peanuts. Michigan does not produce rice, cotton, or peanuts.[7]

Disaster payments encourage farmers to plant commodities on more "risky" croplands. In cases of unfavorable weather conditions or any other for of natural disaster, the farmers would receive federal disaster payments on the commodities lost. There is considerable concern about the future and effectiveness of disaster payments since the applications for assistance in emergency situations is increasing and encourages farmers to plant on lands which may be prone to crop failure, i.e. plant on lands which may be highly erodible or have other agro-environmental problems.

A "Cross-compliance" requirement of existing participants of farm programs such that more environmental quality oriented practices are followed, is one policy alternative. However, this alternative presupposes that most agro-environmental problems occur as a result agricultural production on farms already enrolled in commodity programs. It is possible that significant agro-environmental problems occur on land that is used for the production of agricultural products which do not receive commodity payments. For example, fruits and vegetables use chemical inputs, and, therefore, are a potential cause of nonpoint source pollution but they are not included in commodity programs. There

[7]Commodity program payments in 1991 range from $0 to $6.6 million per county, with most of the funds distributed in the Thumb area, and the central and southern central counties of Michigan. The payments were distributed in all of the counties in which most of the crop and livestock production take place. Essentially no payments ($0.1 to $0.08 million dollars) were distributed in most of the Upper Peninsula, with the exception of Chippewa and Menomenee (receiving $0.08 to $0.52 million), which produce relatively small amounts of crops and livestock.

may be a need to monitor the potential impacts of the chemical inputs on fruits, vegetables and crops.

1.5 Green Support Payments as a Policy Option

A variety of alternatives, including "green payments," for farmers to pursue environmental goals have been proposed a replacement for federal farm programs.[8] Specifically, it has been suggested that current farm programs can be changed to "pay" farmers to adopt "green practices," rather than "pay" them for production yields. Some versions of green payments would require producers to adopt certain conservation practices in order to qualify for USDA commodity support programs. That is, based on specific environmental objectives, participating farmers would receive "green payments", (or "green subsidies") instead of the traditional farm program benefits. Or, green support payments could replace CRP payments with payments for land idling to farmers who

[8]Policy-makers are debating the 1995 farm bill as an opportunity to develop future strategies for agro-environmental issues. In addition, there is debate outside the farm bill with respect to nonpoint source pollution. For example, states and the Environmental Protection Agency (EPA) are currently discussing a new approach for prioritizing federal funds for state-directed nonpoint source pollution cleanup regarding agro-environmental problems. States are concerned about the "alliance" between them and the EPA, because the EPA's watershed approach may cost them flexibility in controlling the funds from their State Revolving Loan Funds (SRF), and it may cause ambiguous management objectives. However, the EPA is proposing that states would administer the projects, while the EPA would provide the oversight of the program. The EPA is proposing to "make a protocol to give states the water quality information they need on a watershed by watershed basis" (Environmental Policy Alert, 1995). One agency source mentioned that the reason for this protocol is that the EPA can then determine if a nonpoint source pollution project would be eligible for State Revolving Loan funding. This program, however, is still under consideration by the policy makers of the states and the EPA and will be discussed further in chapter 4 when new approaches to reduce, or eliminate) nonpoint source pollution stemming from agriculture.

engage in environmentally friendly agricultural practices which conserve soils, improve water quality, improve wildlife habitat, and protect endangered species. The green payment concept assumes that the design is one of positive financial incentives rather than regulation or taxation to achieve environmental goals. Which approach to use is an important policy question involving equity; fairness; enforceability; administrative costs as well as other concerns.

These "green payment" agreements would potentially eliminate some of the inconsistencies of federal farm programs, which, at present, can discourage conservation practices. In concept, these green payments could be distributed on the basis of an "index", similar to the Environmental Benefit Index of the current CRP, which measures the ratio of environmental benefits to federal program costs. The problem is how to design a green payment program which would be politically acceptable and financially affordable in lieu of existing commodity programs or CRP.

What appears to be a simple concept on initial examination eventually raises many practical questions about the design and implementation of a green payment program. A primary problem with the design of a green payment program is the design of criteria for the selection of who is to receive green payments. Additionally, there is a need to identify the trade-offs between the different options for green program policy design.

Knutsen and Woods (1995) raise a variety of additional questions which will ultimately have to be answered.

1.) What level of payments are required to persuade farmers to adopt environmentally friendly production practices?

2.) How would the production practices be derived and what level of monitoring would be necessary to verify their use?

3.) Would the green payment program impose farm size restrictions?

1.6 The Targeting of Green Payments

Targeting consists of the selection of critical regions, such as a watershed, critical land within the region, farms, or specific practices for agricultural production for the green payment program implementation. Targeting of green payments would be directed toward environmental priority concerns such as surface and groundwater quality, wildlife habitat, and/or soil erosion.

There are many issues to resolve with a targeting program. For example, in order to achieve the goal of improving environmental conditions by reducing agricultural nonpoint pollution, it is necessary to determine whether existing or potential environmental problems will be targeted. Depending on the choice, the resulting green payment schedule will have different distributional impacts. For example, in regions with high livestock production, there is the possibility of manure runoff, which constitutes a potential environmental problem. However, if the soil conditions are favorable and adequate cropland is available for spreading manure, such that the manure will do no great harm to surface or groundwater, the allocation of green payments would be different than if payments were allocated to the lands which have actual manure runoff problems as measured by water quality. Data limitations usually suggest that targeting would be done on the basis of potential agro-environmental problems. Then, environmental priority concerns could be incorporated into an Environmental

Vulnerability Index (EVI) which would involve variables such as soil erodibility, manure runoff rates, leaching and runoff of pesticides and nitrogen, and endangered species. The EVI could then be used to target. Once potential problems are identified, future analysis would be required within the targeted region as to whether changes in farming practices are required to remediate or prevent actual problems from occurring.

For a green payment program, it may be possible to target payments to existing CRP participants. This targeting option presupposes that agro-environmental problems occur as a result cropping CRP land on farms enrolled in CRP. However, it is possible that agro-environmental problems occur on land that is already idled (e.g. without winter cover or filterstrips) or is used for emergency weeding or haying. Additionally, CRP is primarily targeted to certain crop production, and the farmers engaged in livestock, fruit, and vegetable production do not receive CRP payments. However, fruits and vegetables may use more chemical inputs than field crops, and, therefore, are frequently a cause of nonpoint source pollution. Actual data for chemical inputs per farm and commodity is important in a complete analysis. Livestock production also is a potential pollutant source.

If the targeting alternative would incorporate potential environmental problems based on the environmental vulnerability index, and farming operations whether or not they participate in CRP, the distribution of payments could potentially address many of the priority agro-environmental concerns. However, it cannot be assumed that all existing problems will be addressed unless the environmental vulnerability index designates all significant agro-environmental problems.

Targeting of green payments based on the severity of actual environmental problems, or environmental "hot spots," regardless of participation in the CRP is likely to benefit groups which do not currently receive CRP or commodity program payments such as fruit, vegetable, and livestock producers operating in environmental "hot spots". Environmental "hot spots" involve areas where environmental problems are known to exist, such as an entire watershed. Enterprises within these areas would receive green payments upon adoption of improved agricultural production practices or systems (which could include land idling).

The question posed is should current CRP participating farms no longer receive CRP benefits if there are no significant agro-environmental problems associated with their farm production.[9] If only farms which are currently enrolled in CRP were to receive green payments upon the discovery of actual environmental problem, there is a possibility that a portion of the current participants would no longer receive benefits. The decrease in benefits would result from the possibility that not all producers who receive CRP payments are environmentally damaging practices. On the other hand, location of existing agro-environmental problems may be overlooked because the operations are not enrolled in CRP.

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[9]The possibility for both unwanted strategic behavior (i.e. pollute intentionally to obtain payments) and for unfairness (i.e. "bad actors" get payments and "good stewards" do not), is apparent with this approach. A possible way to reduce this risk is to "certify" good stewards and good stewards get green payments. The tradeoff here is that such a program can easily expand to include most producers whether or not their farm has or would ever be a contribution to an agro-environmental problem. Certification would probably have to be constrained to "good stewards" within a targeted region only for this reason.

Another important policy question then is targeting to what? Targeting on the basis of certain agricultural practices or systems rather than on the basis of enrollment in CRP, would mean that a farm would only receive green payments if certain environmentally friendly agricultural practices are being employed, the land is idled, or a combination of the two. This targeting option would essentially ignore the specific environmental issues and only focus on whether a farm changes its production practice. Improved farm practices could include implementation of farm plans, such as integrated pest management, or manure management, or the adoption of whole farm planning (rather than planning for specific fields). Particularly, it would need to be determined if farms would receive green payments based on existing or planned environmental practices. For example, some farms already have improved production practices put in place by the CRP compliance provision, while other farms may be planning to implement environmentally friendly practices at some point in the future. If the targeting alternative would include operations which have not yet installed improved production practices, the resulting distribution of green payments may lead to accusations of penalizing those farms which have already made an effort to reduce the environmental damages from their production methods, and rewarding those who have not.

Of course, the distribution of green support payments based on agricultural practices would be different from a targeting scheme based on farm income as would the resulting environmental impacts. Another important question is whether there should be a limit on the annual income of farms who receive green payments or whether all income ranges should be eligible for green payments.

The requirement of certain agricultural practices or systems are termed the requirement of "design" standards. Design standards, may be difficult to ascertain and to measure. This option would essentially ignore any environmental criteria (that is, performance standards) by which to judge whether the green payment program is successful, as long as certain objectives within the design of the program are met. For example, the program may be considered successful if all eligible farms are enrolled into the program whether or not there has been an improvement in environmental quality. Additionally, it must be determined whether the green support program will be for entire farms, or only environmentally vulnerable sections of the farm. In some cases it would not be necessary to enroll the entire farm if, for example only one field were subject to, say, high erosion or runoff.

The income distribution effects of a targeting alternative that is not focused on current recipients of CRP or commodity programs is likely to be substantially different from one that is so focused. At present, the majority of CRP or commodity benefits accrue to those farms which produced the largest amount of field crops. Therefore, the distribution of payments would differ depending on whether targeting green payments benefits would involve participants, or nonparticipants, or a combination of both. For example, if the majority of nonparticipants grow fruits, vegetables, and livestock and which significantly contributes to nonpoint pollution, but current CRP participants are targeted to receive green payments, then the program would miss some areas of environmental concern, and the effectiveness of the program would be diminished.

1.7 Thesis Objectives

This study analyses the effects of alternative Green Support Programs. In order to determine a policy option that will achieve the environmental objectives of reducing nonpoint pollution, data on the location of potential agro-environmental problems in Michigan will be collected.

The potential agro-environmental problem data will be used to form an Environmental Vulnerability Index based on a similar index developed by the Economic Research Service of the US Department of Agriculture (1994). The index will assist in the identification of the location, magnitude, and nature of agro-environmental problems.

Michigan was chosen as a case study because of the agricultural diversity of the state, as well as the extent of nonpoint pollution from agricultural practices and the importance of the Great Lakes Basin. Michigan, therefore, serves as an illustration of the ways in which the targeted agricultural population will be affected by a distribution of benefits from alternative green payment program rather than traditional farm program benefits and CRP payments.

Michigan's agricultural production ranges from commodities which have lands idled under CRP (e.g. corn and wheat croplands), to livestock, fruits, and vegetables which receive no CRP benefits. The case study approach has the advantage of providing an in-depth analysis of the differences between CRP payments and environmental problems. The distributional impacts of different green payment alternatives can then be analyzed.

Agro-Environmental problems stemming from agricultural production exist in many areas of the state, including soil erosion in the Saginaw Bay area, surface and groundwater quality problems in the southwest of the state due to livestock, and crop production, and pesticide leaching from fruit and vegetable production in the Traverse City area of the northwest. The data and resulting analysis makes it possible for states to identify the relationship between agricultural production and probable agro-environmental problems areas. Additionally, data gaps can be identified to improve agricultural policy making.

The purpose of the study is to analyze the distributional impacts of agricultural policy alternatives based on different green payment targeting schemes on a county basis. The primary objective of this study is to quantify how the county beneficiaries differ under the two policy alternatives. The hypothesis of this study is that the Conservation Reserve Program is poorly correlated with the agro-environmental problems in the state of Michigan. Specifically, this study has the following objectives:

(1) to identify the location of environmental problems as well as existing CRP payments in Michigan by constructing an Environmental Vulnerability Index (EVI), through the use of potential as well as actual data on environmental variables.

(2) to develop alternative green payment programs (including cropland idling programs) that compare and contrasts with the location of current (1991) CRP payments

  2.1 Targeting based on all potential environmental problems as incorporated in by the Environmental Vulnerability Index

    2.2.1 Targeting based on potential erosion problems
    2.2.2 Targeting based on potential surface water problems
    2.2.3 Targeting based on potential groundwater problems
    2.2.4 Targeting based on manure problems
    2.2.5 Targeting based on threatened and endangered species
    2.2.6 Targeting based on potential wildlife habitat problems
    2.2.7 Targeting based on potential pesticide problems with respect to fruit, vegetable and crop production

(3) to identify some alternative Best Management Practices (BMP's) or Best Management Systems to obtain environmental quality goals.

(4) identify critical environmental areas which contribute to nonpoint-source pollution, in order to partially validate the Environmental Vulnerability Index by

4.1 identifying agricultural land use patterns by county by using GIS

4.2 identifying animal waste loading by county by using GIS

4.3 identifying the use pesticides on fruits by using GIS

(5) to identify and discuss

5.1 implementation of alternatives targeting schemes (voluntary vs. mandatory, state vs. federal)

5.2 various vehicles of program payments.

This study is organized around these objectives. Chapter 2 will describe the data as it relates to Michigan. Chapter 3 will develop an alternative green payment program, including a development of appropriate BMP's, and compare the resulting distribution of payments to the existing distribution of commodity program and CRP program payments. Chapter 4 will identify the potential agro-environmental problems in Michigan and compare potential agro-environmental problems in Michigan and the existing commodity and CRP program payments. Chapter 5 will examine the difficulties of alternative green support programs with respect to the implementation of a green support program, budget constraints, data limitations administrative issues, and other policy implications.

1.8 Methods and Data Requirements of This Study

Following is a brief description of the methods and data requirements to achieve each objectives. The data requirements are explained and the origin of the data collected is cited.

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1.8.1 Objective 1: Environmental Vulnerability Index (EVI)

The first objective is to determine the location of potential agro-environmental problems in Michigan on a county basis. The identification of potential agro-environmental problem areas is important in order to determine the areas which should be targeted for alternative green support programs and which counties would retain CRP payments if CRP were to be retargeted to specific agro-environmental problems. In order to design a green support program that potentially reduces environmental damages from agricultural practices, it is necessary to also determine which land is eligible for support.

County data was used because site specific agro-environmental problems data was not available. To achieve objective 1, an Environmental Vulnerability Index (EVI) will be used. The index provides an aggregated measure of various potential environmental problems as they relate to the agricultural profile of each county in the state. An Environmental Vulnerability Index can be used to identify the counties in Michigan which could be used for a targeted green support program.

The Environmental Vulnerability Index will be developed from an existing index ("Environmental Benefit Index" or EBI) designed by the Economic Research Service (ERS) of the United States Department of Agriculture (USDA). This index was also used for the retargeting CRP for post 1990 CRP contracts. The Environmental Benefit Index was used to proxy potential environmental damages from agricultural production. The index was used to demonstrate the potential benefits from conservation programs which are aimed at improving environmental conditions. Thus, the environmental benefit index has been d

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The EBI of the Economic Research Service contains national data regarding surface water quality, groundwater quality, soil erosion, wildlife habitat, and other variables. The data was obtained from the 1982 National Resource Inventory (NRI) points, of which there are 323,000 in Michigan (United States Department of Agriculture, Handbook 296). Specifically, indicators of surface water quality problems use proxies for actual water quality variables such as sediment production, nitrogen runoff, and the presence of cropland near bodies of water (where the potential for filterstrips exists). Groundwater quality indicators also use proxies which include potential pesticide leaching and potential nitrogen leaching. Wildlife habitat problems are proxied by the potential for wildlife habitat improvement as well as species threatened and endangered by agricultural development. Soil erosion problems are measured by potential soil productivity loss, and potential windblown dust. Other indicators include potential exposure to agricultural pesticides and the potential for a reduction of flood damage through wetland restoration in floodplains. The Environmental Vulnerability Index (EBI) was based on both the physical attributes of the environmental indicators and the physical attributes of the environmental problems based on socioeconomic weighing (population or economic value). These variables and the index are discussed in greater detail in chapter 2.

The Michigan Environmental Vulnerability Index ideally would measure all potential environmental problems resulting from agricultural production. Broadly defined, agricultural farming practices can affect surface and groundwater quality, wildlife habitat, and soil erosion rates. In order to proxy environmental quality in Michigan, the following county level variables will be extracted from the national Environmental Benefit Index:

(1) Potential soil productivity loss
(2) Potential nitrogen runoff
(3) Potential windblown dust
(4) Potential sediment delivery
(5) Potential pesticide leaching
(6) Potential nitrogen leaching
(7) Potential for filter strips
(8) Potential pesticide exposure
(9) Threatened and endangered species
(10) Potential habitat improvement

The data for the above variables were provided by the Resource Policy Branch, Resource and Technology Division, Economic Research Service (ERS), United States Department of Agriculture. Since the variables for ERS's Environmental Benefit Index was developed to demonstrate environmental problems on a national level, the data for Michigan will be extracted. All indexes in the EBI are on a national level, and were normalized to a 0-100 interval by ERS. For example, Suffolk county (NY) displays the maximum value (index=100) for potential nitrate leaching. Although environmental nitrogen problems are prevalent in the state of Michigan (particularly around Lake Michigan), it is not perceived as a large problem on a national level.

The variables used from ERS are both weighted and unweighted by population . Although the unweighted variables will be used, the weighing by the population density can be used as a "measure of conflict," as well as the demand for improvement in agroenvironmenta

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environmental policy making. Specifically, the higher the population density in a given county or watershed, the more potential conflict exists between people and environmental quality. For example, weighing sediment production by the population of watersheds which are potentially affected by sediments delivered to the water bodies reduces the importance of sediments which are produced in areas that are sparsely populated (Heimlich, 1994, p. 4).

1.8.2 Objective 2: Targeting Alternatives

In addition to a qualitative analysis of the incidence of environmental problems in relation to commodity programs and CRP, alternative green payment programs will be examined. The resulting distributional impacts will be analyzed.

Different targeting alternatives are considered, which include targeting to potential problems using the Environmental Vulnerability Index. The EVI is composed of: (1) soil erosion, (2) surface water, (3) groundwater, and (4) wildlife habitat considerations. Also, the EVI enables a composite of potential environmental problems to serve as a basis for targeting the green support program. Specifically, the targeting options include:

(a) target existing CRP participants (on a county basis) for permanent easement or conservation practices,

(b) target existing CRP participants (on a county basis) for adoption of Best Management Practices (BMP's), or whole farm systems.

(c) target potential agro-environmental problems (on a county basis) regardless of participation in commodity programs for adoption of BMP's.

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(a) Use Existing CRP for Long-Term Easement

One possibility for a targeted green payment program is to continue some lands in the existing CRP under long-term conservation easements. As CRP contracts begin to expire in 1995 and annual rental payments are discontinued, there is growing concern as to what should be done with the land currently enrolled. A continuation of the CRP in its current form may not be politically feasible, or even environmentally advisable, due to the nature of the land enrolled and changing environmental priorities. However, if the CRP continues in a modified form, environmental benefits can still be realized. Highly erodible land and land vulnerable to water quality damage could be taken out of production and set idle for an extended period of time. As under the CRP, operators would receive rental payments for enrolled land or a single lump sum payment.

To investigate this proposed alternative, first, highly erodible land, as determined by the soil tolerance level, will be taken out of production. Moderately to slightly erodible land will remain under cultivation. Secondly, erodible land which is close to a body of water would also be idled, resulting in a reduction in sediment runoff into surface water. This alternative would substantially reduce nonpoint-source pollution.

(b) Adoption of Best Management Practices (BMP's) by CRP Participants

A second alternative which is examined is the combination of green payments and the adoption of certain BMP's. With this alternative, if farm operators adopt certain environmentally friendly practices or systems, currently CRP enrolled participants will be eligible for CRP payments or green support payments. Examples of BMP's include biologica

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biological pest control, manure storage management, and nutrient management. Even though BMP's are more likely to be environmentally enhancing, some BMP's are also likely to produce more fluctuating yields and, therefore, in some cases, may lead to a reduction in productivity of the farm operation.

There are concerns as to the "fairness' of this alternative. Enterprises which are currently enrolled in commodity programs are required to adopt BMP's if they contribute to agro-environmental problems. However, enterprises which are not enrolled in commodity programs but who have significant agro-environmental problems on their farms will not be eligible for support with this alternative. Likely enterprises that would be excluded are fruit and vegetable production, as well as certain livestock operations.

(c) Adoption Of BMP's In Areas Where CRP Is Low Or Nonexistent

The third targeted green payment program alternative is to include all potentially polluting enterprises, regardless of whether they are currently enrolled in CRP, and therefore, those enterprises engaged in agricultural production. However, equity issues may also be significant. With this alternative, farm enterprises would be eligible for green payments if potential agro-environmental problems resulting from their land are identified, and if the farms adopt certain BMP's or systems. It is possible, that current CRP payment recipients may receive considerably less benefits because the agro-environmental problems are not severe enough to justify any conservation payments. Therefore, the reduction in income for the enterprises which currently receive CRP benefits may be significant.

(d) Green Payments on the Basis of the Environmental Vulnerability Index

Another targeted option is to distribute benefits to enterprises only within the regions of the high values of the Environmental Vulnerability Index. Under this green payment program, counties which are most environmentally vulnerable will be affected, and the enterprises within these areas will be eligible for payments if production practices are changed to improve the potential agro-environmental problems within the region, regardless of whether farmers are participants in CRP. Specifically, each county in Michigan will be divided into classes based on the EVI variables. Each county then will receive a ranking from high to low based on the environmental problems present as represented by the EVI. Green payments will vary depending on the ranking of each county; the higher the EVI number, the higher the green payments to that county's farmers since presumably more environmental problems are present.

Although this option is environmentally enhancing, since it targets potential agro-environmental problems, equity concerns become apparent. If current CRP beneficiaries are different from those who operate the enterprises which display the most significant potential agro-environmental problems, such as fruits and vegetables, there is likely to be a substantial income redistributional effect of this alternative from existing CRP and commodity programs.

(e) Nature and Definition of Green Payment Schedule including BMP's

This objective is discussed in detail in chapter 3.

1.8.3 Objective 3: Critical Environmental Areas

The third objective is to identify the location of critical agro-environmental problems which contribute to nonpoint-source pollution. The Environmental Vulnerability Index will be provided on a national basis, with the data for Michigan's counties extracted. This objective attempts to examine whether the state-wide data is an appropriate proxy for matching agricultural land use patterns by county with the potential agro-environmental problems from ERS.[10] Additionally, animal waste loading by county will be identified, since the EVI does not include potential manure problems in their data set. Thus, critical areas and specific agricultural practices within the state of Michigan are identified through the maps generated from the potential environmental variables provided by ERS. Specifically, the question posed is whether the EVI correctly predicts where critical environmental problems are located. Agricultural production patterns which contribute to nonpoint-source pollution are identified in order to determine the criteria by which to design the green payment program schedule.

(a) Agricultural Land Use Patterns

Agricultural land use patterns of Michigan counties are identified using data from agricultural statistics, and data maps will be generated. County maps describe the agricultural production for each county to locate the areas in Michigan which are not

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[10]ERS's data set is based on agricultural land use patterns. However, the data is based on field crops such as corn, wheat, soybeans, cotton, and rice. Thus, it is important to determine if the data set is still valid for Michigan.

participating in commodity programs or CRP as well as to identify the environmentally vulnerable areas. These locations, as well as the locations of commodity program and CRP participants are subsequently matched with the potential agro-environmental problems in the regions. The necessary data is on a county level compiled from Michigan Agricultural Statistics for 1991 and 1992, the 1991 Fruit Rotational Survey, and the 1992 Census of Agriculture for Michigan, which include:

(a) confined animal units by county
(b) fruit production
(c) vegetable production
(d) field crop production

(b) Animal Waste Loading

The data for confined and unconfined animals will be collected from the Census of Agriculture (1992). The confined and unconfined animal production will then be used to determine the potential environmental problems from manure runoff into lakes and streams by multiplying the number of animals with their respective manure production rates. Additionally, the nitrogen and phosphorous contents of manure will be calculated. Both manure production per animal and their respective nitrogen and phosphorous contents will be calculated using the Manure Management Work Sheets provided by the Cooperative Extension Service as part of the Series on Record Keeping System for Crop Production. The third objective will be discussed in Chapter 3 and 4.

1.8.4 Objective 4: Identification of Commodity Program and CRP Payments

The fourth objective is the identification of commodity program and CRP payments. The agricultural areas which are enrolled in the commodity programs and the

CRP will be identified in order to examine the relationship between commodity programs, CRP and the incidence of potential nonpoint-source pollution.

The amount of money spent on CRP in 1991 will be used as the budget constraint for the distribution of green payments. The county level data for commodity as well as CRP payments will be obtained from the Environmental Working Group, a non-profit environmental research organization based in Washington DC. This objective is analyzed in Chapter 4.

1.8.5 Objective 5: Examination of Impacts

Objective 5 is the examination of the impacts resulting from alternative green payments programs. To improve environmental quality, it is necessary to identify the location of environmental problems and the practices which cause these problems. The enterprise-specific location will then be matched with the counties which currently receive commodity program and CRP payments. It is probable that the proposed green payment schedule will distribute payments differently than commodity program or CRP payments, regardless of which targeting approach is taken as long as the environmental objectives are met. This section of the study will examine the distribution of payments resulting from the targeting alternatives on the county basis. The distributional effects include (1) spatial differences, and (2) differences between enterprise types. While the implementation costs of each targeting scheme are important, as well as the costs to farm operators by changing certain production or farm management practices, such estimation is not part of this study. This objective is discussed in Chapter 5.

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Since most of the agro-environmental problems are on a county basis and are based on potential, not actual problems, there is a need to collect actual data on agro-environmental problems in order to improve the analysis. However, some agro-environmental problems such as the production of animal manure could be calculated from existing livestock numbers. Additionally, the analysis is on a county basis, and research based on regional or site-specific data regarding production and agro-environmental problems may help policy makers to make potentially more accurate environmental policy decisions.

Chapter 2

Agro-Environmental Problems: Data Availability

The first objective of this thesis is the description of the agricultural production and potential and actual data availability. This section describes the relevance of the variables to be used in the Environmental Vulnerability Index (EVI), as well as the data used and the manipulation of the data in the process of constructing the variables. The purpose for the discussion of the data and their relevancy is to investigate whether federal farm programs and the Conservation Reserve Program (CRP) are adequate to serve as a basis for green support programs designed to reduce agro-environmental problems. Maps are generated for a visual inspection of all variables. All maps can be found in Appendix F through O.

All data are on a county basis for Michigan. The data can be grouped into four types: (1) acres of agricultural production for the state of Michigan, (2) the potential environmental problems stemming from agriculture, and (3) commodity program payments and Conservation Reserve Program (CRP) payments. The grouping into these four categories serves to examine whether the potential environmental problems match the agricultural production pattern in Michigan, since the data was extracted from a national data base provided by the Economic Research Service (1994).

2.1 Agricultural Production Data

Agricultural production data was collected from the Agricultural Census (United States Department of Agriculture, 1992), Michigan Rotational Survey, and the Michigan Agricultural Statistics (Michigan Department of Agriculture, 1993) to identify the potential sources of agricultural nonpoint-source pollution. The agricultural production measured for the purpose of this study is defined as (1) fruits and vegetables measured in acres, (2) livestock production measured in number of animals, and (3) crop production measured in acres. Additionally manure produced by livestock is calculated.

2.1.1 Fruits and Vegetables

Data for fruit and vegetable production was collected in acres planted per county from the Michigan Rotational Survey for the year 1991. The reason for collecting fruit and vegetable production data for 1991 is because the CRP and Federal Commodity Program Payments are only available for the year 1991. The acreage for fruit is defined as acres planted to apples, tart and sweet cherries, blueberries, grapes, peaches, prunes and plums, nectarines, apricots, and brambles. Vegetable acreage was reported for both fresh and processed products and includes asparagus, beans, cabbage, carrots, cauliflower, celery, cucumber, green peas, potatoes, and tomatoes. The following fresh vegetables destined only for the fresh market were reported in acres: cantaloupes, sweet corn, dry onions, green peppers, pumpkins, summer and winter squash, and strawberries.

Acres planted for both fruits and vegetables were summed to obtain the total acreage planted of fruits and vegetables per county in Michigan. The data was used for the purpose of generating maps using Atlas Geographic Information System (GIS)

(Strategic Mapping, Inc., 1994) to locate the regions potentially vulnerable to pesticide exposure. Fruits and vegetables are reported in acres of fruit production in 1991 (Map F.1 and F.2, Appendix F). From the maps it is clear that the fruit production is heavily concentrated on Michigan's western shores, although there are some orchards and fruit production operations in other regions of the state, however, these operations are not reported due to confidentiality restrictions. Vegetables are broadly distributed in the southern region of the Lower Peninsula.

2.1.2 Livestock

Data for livestock inventory in animals per county were obtained from the Michigan Agricultural Statistics (1993) for the year 1992 to establish a variable for manure production and, consequently, potential harm to the environment from excess nutrients and bacteria. Livestock include cattle (calves, dairy and beef cows), hogs and pigs, hens and pullets, and sheep and lambs. The production of turkey was not reported on a county basis in any published source due to the relatively few producers in the state, and census confidentiality requirements. The number of turkeys per county has been estimated by Professor Cal Flegel in the Department of Animal Science at Michigan State University in a telephone conversation (Flegel, 1995). The number of animals were then converted to animal units per county through the Animal Unit Conversion based on the Federal Code of Regulation. Animal Units are mapped for the year 1993 (Map F.4, Appendix F). From the map, it can be observed that animal units are concentrated in the

Thumb and in the south western counties of Michigan, however, many of the livestock operations can also be observed in the west and south central region of the state.[11]

2.1.3 Manure

The manure production calculation was based on the Manure Management Sheets, Record Keeping System for Crop Production, Cooperative Extension Service Michigan State University, (Extension Bulletin E-2344, 1993). The Work Sheet provided multiplication factors for dairy cattle (weight categories of 150, 250, 500, 1,000, and 1,400 pounds (lbs)), beef cattle (500, 750, 1,000, 1250 lbs, and separate multiplication for a beef cow with a weight between 1,000 and 1250 lbs), swine (nursery pig 35 lbs, growing pig 65 lbs, finishing pig 150 lbs, finishing pig 250 lbs, gestating sow 275 lbs, sow and litter 375 lbs, and boar 350 lbs), sheep (100 lbs), horses (1,000 lbs), and poultry (weight categories per 100 birds of turkeys 16 lbs, chicken layers 4 lbs, chicken broilers 2 lbs).

The data for livestock production are reported in head of animals per county, however, they do not record the number of animals according to the size of animal for each county, thus, certain assumptions regarding the weight of the animals had to be made. Specifically, since the data on livestock was reported in general numbers, rather than according to weight per animal, the number of animals in a county was divided into average sizes when possible and multiplied by a factor to estimate cubic feet of manure

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[11]Manure production is mapped in Appendix I, Map I.4. The ranges only appear to overlap, however, the ranges are such that the calculation of quantiles (equivalent to quartiles) takes that fact into account and no overlapping occurs.

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per year per animal. The worksheet for manure conversion was divided into weights of various animals. In order to obtain the manure output per animal, the calculations were as follows: the multiplication factor (no units given) for beef cows was taken to be 380, while milk cows were multiplied by 680 (assuming dairy cows to be an average size of 1,400 lbs), and the number of calves were multiplied by 180 for an average size of 500 lbs. Hogs and pigs were distinguished between nursery pigs (<60 lbs, multiplication factor 14), growing pigs (60-119 lbs, factor 26), finishing pigs (120-179, factor 58; 179>, factor 80), and breeding pigs (350 lbs, factor 69). The average weight of sheep was assumed to be 100 pounds, thus, the number of animals in each county was multiplied by 23. Poultry was distinguished between turkeys, chicken layers and chicken broilers. The number of turkeys was multiplied by 510 per 100 birds. To distinguish between chicken layers and chicken broilers, it was assumed that the production of both is equally distributed between counties. Therefore, the number of hens and pullets was multiplied by the average multiplication factor for layers and broilers (factor 109).

The sum of the resulting values approximated the total volume of manure produced annually in each county in pounds. For ease of interpretation, total pounds of manure were then converted to millions of pounds. Additionally, the nitrogen and phosphorous contents of manure for each animal was calculated by multiplying the animals per county according to animal species and size by the appropriate multiplication factor for nitrogen and phosphorous to obtain the pounds of nitrogen and phosphorous per year per county.[12] Subsequently, the numbers were converted to millions of pound per county per year and mapped with Atlas GIS (Map I.4, Appendix I).

The presence of pathogenic organisms, nitrate, phosphorous, and ammonia in manure discharged into surface water contributes to the contamination of water quality. For this study, "Manure Runoff Rates" is the variable by which the vulnerability of surface waters in each county can be determined. In this study, manure rates are estimated by animal units in the counties, and by manure production rates per animal. The nitrogen and phosphorous rates in the manure are then multiplied with the manure production estimates in order to approximate the amount of nitrogen and phosphorous which may be delivered to lakes and streams.

Confined and unconfined animals consisting of cattle, hogs, poultry, and sheep, are primarily located in the Thumb area of the state (Huron county), as well as the south western counties of Ottawa, Allegan, and Ionia. As expected, the resulting map demonstrates that most manure is produced in the Thumb area of Huron and Sanilac counties, the south west and south central regions. Additionally, moderate amounts of manure are produced in Menomenee county of the upper peninsula, mainly from beef cattle (see Animal Units Map, F.4, Appendix, F)

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[12]The multiplication factors for the nitrogen and phosphorous contents are as follows: dairy cows (x210; x85), beef cows (x130; x100), calves (x62, x46), nursery pigs (x5.8; x4.3), growing pigs (x10; x8.1), finishing pigs (x25 and x33; x18 and x33), breeding stock (x28; x22), sheep (x16; x5.5), turkeys (x4.2; x3.6), chickens (x0.99; x0.68).

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2.1.4 Crops

Data for crops were collected in acres planted per county from the Census of Agriculture for the year 1992. Area planted rather than area harvested was chosen to account for weather induced harvest fluctuations. Crop acres are defined as corn, wheat, soybeans, oat, all dry beans, barley, potatoes, and sugar beats. The crop acres were summed across all crops to obtain total crop production per county in Michigan. The summation of the area was then mapped using Atlas GIS to compare it to the environmental problems in the state as well as the distribution of commodity programs and CRP. Crops are reported acres of crop production per county for the year 1992 and can be seen on Map F.3, Appendix F. Crops are heavily concentrated in the Thumb and the lower half of the Lower Peninsula, although some crop production occurs in the Upper Peninsula.

2.2 Environmental Data

Environmental data includes a data set provided by the Economic Research Service (United States Department of Agriculture, 1994) which consists of potential agro-environmental problems data. Additionally, manure production and its dangers for runoff is included as well as the phosphorous and nitrogen contents of manure. Furthermore, a data set provided by Lee and Lovejoy (1994) for the potential for filterstrips based on slopes and cropland was included.

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2.2.1 ERS Environmental Data

Ideally, the data for environmental problems would include variables such as ground and surface water quality (pesticide, nitrogen leaching and sediment runoff), soil erosion damages, and damages to wildlife habitat stemming from agricultural production. Such data does not exist at a state level of coverage. The lack of such data made it necessary to use "proxies" for agro-environmental problems in the state. One data set developed by the Economic Research Service (ERS) of the United States Department of Agriculture (USDA) models the potential environmental problems resulting from US agriculture. Originally, the data set was developed as environmental indicators for proposed legislation 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 damage" (Heimlich, 1994).

The complete nationwide ERS index is based on data for the 323,000 cropland points in the 1982 National Resources Inventory (NRI), matched to their respective soil interpretations from the SOILS 5 database, the Soil Interpretive Record.[13] The original NRI SOILS 5 database was created using polygon overlay techniques.[14] The data were originally mapped to 18,530 NRI polygons, and a three way layering of county, major

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[13] The National Resources Inventory (NRI) is a multi resource inventory which is conducted every five years by the USDA's Soil Conservation Service (SCS) and consists of databases regarding the status, condition, and trends of water, soil, and related resources. Specifically, information in the data base include: soils, land cover, land use, cropping history, conservation practices, conservation treatment needs, potential cropland, prime farmland, highly erodible cropland, water and wind erosion, wetlands, wildlife habitat, vegetative cover conditions, irrigation, and flood susceptibility.

[14] A polygon is a "closed plane figure bounded by straight lines. By making straight-line segments small, curved boundaries can be closely approximated." Therefore, the shape of a polygon is created from curvilinear boundaries (Aronoff, 1989, p. 39).

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land resource area (MLRA), and hydrologic unit boundaries was used. The hydrological units boundaries (watershed boundaries) were developed by Margaret Maizel (National Center for Resource Innovation) in cooperation with the Economic Research Service (ERS) of the United States Department of Agriculture (USDA).

Hydrological units consist of polygons which carry 8 digit identifiers defining accounting units, cataloging units, subregional units, and regional watershed units, as well as administrative boundaries of the US Water Resources Council (Maizel and Muehlbach, 1992, p. B-2). MLRA's consist of "geographically associated land resource units" (US Soil Conservation Service, 1982, p. 1).

A cartographic database was created consisting of county boundaries, MLRA boundaries, and the hydrological unit in which the MLRA is located. These boundaries were overlaid resulting in polygons in which the sampling took place. The polygons created by the intersection of the boundaries then provide geographically identifiable locations for referencing and distributing each sample point in the NRI inventory. "These polygons, together with the collection of NRI sample points belonging to them, 1) permit analysis based on site-specific, co-located information on land use, soil type, and other geographically indicated overlays, such as average precipitation and climate; and 2) provide physiographical units for aggregating to larger regions by taking advantage of the statistical properties of the NRI database" (Maizel and Muehlbach, 1992, p. B-1).

All Economic Research Service indices were developed at the sample point level, and subsequently were combined to the NRI polygon level for the purpose of mapping by taking the acreage-weighted average of the index value. Indices were then normalized to the 0 - 100 interval level, involving a process consistent with the calculation of percentag

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percentages: the average NRI polygon value is divided by the maximum value of the NRI polygon and multiplied by 100. The reason for normalizing the data was that it would be easier to interpret the maps generated by the Economic Research Service. However, the national maps from the Economic Research Service, although normalized index to percentages (0 to 100), in general can be misleading because the data is severely skewed. All variables start with a 0 index, however, the numbers for the ranges may only be calculated up to a low index, which then proceed to 100. The ranges in the national maps can be observed in appendix C, section C.1.

The Economic Research Service data set was reported in a weighted and an unweighted format (Table 1). Table 1 was duplicated from the ERS publication by Heimlich (1994). It includes variables of potential environmental problems, the affected resources, the externalities, the description of the variables, and weights used. The weighted ERS data set was provided in two formats: the variable with the physical properties only and the variables with a socio-economic or population density weighing. "Weighing indices by population, value, or other variables assumed to be proportional to benefits from conservation program changes the magnitude of potential environmental effects compared with unweighted indices" (Heimlich, 1994, p.14).

The population weights approximate potential environmental damages, or the benefits of remediating the environmental problems. Thus, in order to distinguish between the potential environmental damages to surface water and groundwater, the Economic Research Service researchers used different human population density measures to weight the environmental variables.. For example, variables such as potential sediment delivery and nitrogen runoff were weighted by watershed population.

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Environmental variables which could potentially be damaging to groundwater (potential pesticide leaching and nitrogen leaching) are weighted by population using groundwater sources in the counties (Heimlich, 1994, p.18). In some cases, the weighing by population or economic value (as is the case with soil erosion, which is weighted by cash rent to obtain a proxy of soil productivity loss) shifts policy attention to cropland near urban centers and away from rural areas where agriculture dominates economic activity.

Since the State of Michigan has distinct, and well known urban centers, in this study, the unweighted data set will be used. For purposes of illustration, and as a reminder of the importance of the environmental problems near urban centers, some population weighted variables will be shown.

The unweighted ERS data for potential environmental problems in the state of Michigan were extracted from the national data base and mapped using Atlas GIS. The variables (based on quantiles) with the data include:[15].

(1) Potential soil productivity loss
(2) Potential nitrogen runoff
(3) Potential windblown dust
(4) Potential sediment delivery
(5) Potential pesticide leaching

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[15]The data set also includes a composite index which was not used for the purpose of this study. The composite index provides an aggregate measure of agricultural environmental performance, which could then be combined with other factors, either farm or economic. As an example, Heimlich (1994, p.21) cites the combination of the composite index with the distribution of farm program payments to show areas with high relative environmental problems that also receive high levels of agricultural program payments. This study attempts to do the same, although the composite index will not be used. The accuracy of some data is questionable on a state level so that further combination of environmental variables may further compromise the conclusions of the analysis.

Table 2.1:

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Nitrate Leaching
Wildlife Habitat Improvement
Threatened and Endangered Species
Soil Productivity
Windblown Dust
Pesticide Exposure
Flood Peak Reduction

Source: Hei

Table 2.1: Economic Research Service Variables, Affected Natural Resources, Externalities, Description of Variables, and Weights Applied to Variables

Indicator	Affected Resource	Externality	Description	Weight
Sediment Delivery	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	Groundwater population
Nitrate Leaching	Groundwater quality	Nitrate contamination of drinking water supplies (Kellogg et al., 1992)	Nitrate and soil leaching potential	Groundwater population
Wildlife Habitat Improvement	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 ingredients 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

Source: Heimlich, 1994

(6) Potential nitrogen leaching
(7) Potential for filter strips
(8) Potential pesticide exposure (explained in Appendix A)
(9) Threatened and endangered species
(10) Potential habitat improvement

The values in each Michigan county consisted of different MLRA's and different hydrological units. For example, data for some counties had more than one sample point or hydrological unit, all of which were included in the data set. It was necessary to reduce the data to one data point per county for the purpose of mapping; therefore, the data was aggregated, resulting in an average value per county. The procedure of averaging may reduce the validity of the data, but the assumption of accuracy remains. Additionally, since the Economic Research Service values were normalized on a national 0 to 100 interval level, some environmental problems, although problems in some regions of the United States, do not appear to be problems for Michigan.

The maps generated by the Economic Research Service show the location of regions with high potential for the indicated environmental variable. Specifically, darker shaded polygons reflect a higher potential for environmental damage than lighter shaded polygons. To illustrate, the potential for windblown dust (wind erosion) appears to be a substantial problem in the regions of Montana, Texas, Oklahoma, New Mexico, and Colorado (Map J.6, Appendix J). Windblown dust does not seem to be a problem for Michigan, although as a population weighted variable, it can be seen as somewhat of a problem near the urban centers of Detroit and the Saginaw Bay area (Map J.3, Appendix J).

Although sophisticated in design, some of the variables are not an accurate measure for actual environmental damage created by agricultural production but may be worthwhile indicators of potential problems. A brief description of the Economic Research Service's Potential Agro-Environmental data follows, and a detailed discussion of the variables is provided in Appendix D, including justification of the data, the location in Michigan as well as a description of non-ERS provided variables such as manure production. The data are mapped using GIS and the maps are provided in Appendix I through M. A discussion of the location of potential agro-environmental problems, combined with CRP payments, is provided in chapter 4.

2.2.2 Surface Water Contamination

Surface water contamination from agricultural nonpoint pollution, resulting from crop and livestock production, has been a problem in the United States, and, particularly, in Michigan. Surface waters pollution sources in Michigan are nutrient and pesticide runoff and soil erosion. Nutrient runoff is the primary cause of the impairment in estuaries, and coastal zones, rivers and lakes in the United States (National Research Council, 1994, p. 14). In fact, the US Environmental Protection Agency (EPA) identified agricultural nonpoint pollution as a primary cause of stream and lake pollution in the U.S. which prevents the attainment of water quality goals identified in the Clean Water Act.

State-wide data for actual surface water pollution is not available, although there are data sources which estimate the potential for surface water pollution through various sources. There are, however, proxies for actual data which include the calculation of manure production and the calculation of nitrogen and phosphorous contents in the manure from the Manure Management Sheets, (Record keeping for Crop Production, Cooperativ

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Cooperative Extension Service, Michigan State University, Extension Bulletin E-2344, 1993).

Surface water nonpoint pollution may result from animal manure, specifically the nitrogen and phosphorous contents in manure may pollute surface waters.[16] The data from the Economic Research Service (ERS) are included in this study. These data is potential sediment delivery, potential nitrogen runoff, and the potential for filterstrips bordering lakes and streams. For this study, all data sets (Economic Research Service and non-Economic Research Service data sets) and the resulting maps will be interpreted as they relate to the pattern of agricultural production in the state of Michigan.

2.2.3 Nitrogen and Phosphorous as a Problem

Nitrogen is one of the most important plant nutrients. It is also one of the most mobile compounds in the soil (National Research Council, 1993, p. 237). Nitrogen has many sources which can contribute to environmental problems through nitrogen leaching into ground water and nitrogen runoff into lakes and streams. Sources of nitrogen (N) inputs include rainfall delivery, mineralization from soil organic-N, crop residues, manure, and legumes.

Fertilizer is the single largest source of nitrogen and phosphorous applied to croplands. The importance of fertilizers varies depending on the region, however, three crops (corn, wheat, and cotton), use 61 percent of fertilizer nitrogen applied nationwide.

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[16]The Economic Research Service did not include animal manure in their calculation of the indices. The variables of manure production as well as nitrogen and phosphorous contents of manure are separately included in this study.

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In general, almost no fertilizer is applied to soybeans; however, fertilizer applied to other crops such as potatoes and sorghum can be significant. Nitrogen fixed by legumes, such as alfalfa and soybeans, can add substantial amounts of nitrogen to the soil. Nitrogen fixation is the process by which legumes take nitrogen from the atmosphere and incorporate it into the plant's tissue (National Research Council, 1993, p.238).

Animal manure is another important source of nitrogen and phosphorous. The amount of manure nitrogen and phosphorous depends on the type and handling methods used by the producer. Nitrogen and phosphorus applied as fertilizer may not be immediately available for crops. For example, nitrogen in this form becomes available only over time, as it is mineralized, and can contribute nitrogen to crops over several growing seasons.[17]

2.2.4 Manure Runoff, Nitrogen and Phosphorous Contents in Manure

Generally, manure is not considered an asset in providing fertility to the counties' soils. However, there are benefits from using manure in crop production. "Continuous and judicious use of manure improves the physical and chemical properties of nearly all soils ... and the potential for degradation of the quality of soil, air, and water resources is greatly reduced" (National Research Council, 1993, p. 400). Specifically, manure provides essential nutrients for crop growth, as it adds organic matter to soils, improves soil structure, and increases the soils ability to hold water and nutrients. However,

[17] Larson, et al estimated that "9.5 [million] metric tons of nitrogen was lost with eroded soil in 1982, an amount roughly equivalent to the amount of nitrogen applied in synthetic fertilizers in 1987" (as cited in National Research Council, 1993, p. 264).

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manure used as fertilizer is generally not economically competitive because the cost of commercial fertilizer, though increasing, is still lower than the cost of handling manure as fertilizer in most situations.

Today, animal manure is essentially regarded as a waste for disposal. The change in attitudes developed as livestock production became more and more concentrated in specialized large scale operations. Additionally, improvements in the technology and marketing enabled the production and distribution of commercial nitrogen fertilizers at relatively low prices (National Research Council, 1993, p. 400). Thus, manure handling and disposal is becoming a growing concern; there is potential environmental damage caused by manure runoff into surface water as well as nitrogen and phosphorous leaching from manure. Furthermore, the potential harm of manure accumulation around animal drinking locations and grazing operations may be substantial, especially in open and unpaved feedlots. Specifically, the presence of pathogenic organisms, nitrate, and ammonia in livestock drinking water may adversely affect livestock health.

The need for manure as a fertilizer is reduced over time, after repeated applications. When applied to fields, the percentage of nitrogen in manure that is released in the first year increases with the amount of nitrogen in the manure. Furthermore, it takes three or more years before most of the nitrogen is mineralized and available to plants (National Research Council, 1993, p. 405). It follows that the fields need less and less manure to maintain the amount of nitrogen necessary for plants.

Nitrogen and phosphorous, present in manure, are essential for plant growth; however, in excess they can contribute to significant environmental damage, particularly the deterioration of ground and surface water. Besides the problems of nitrogen mentioned above, phosphorous in excess can damage water resources. The ratio of nitrogen to phosphorous in manure generally is 3 or 4. "Since a significant amount of nitrogen is lost by volatilization, the nitrogen to phosphorous ratio of manure applied at rates sufficient to supply adequate nitrogen for most cropping conditions, excess amounts of phosphorous and potassium are added" (National Research Council, 1993, p. 406). Thus, the increase in phosphorous in the soil leads to an increase in sediment-bound phosphorous which can be discharged into surface waters through runoff. Phosphorous in surface water is a major concern in the eutrophication process of lakes.[18]

The nitrogen and phosphorous contents of manure may not always cause an actual environmental problem in the areas affected. The environmental problems, resulting from nitrogen and phosphorous depend on manure handling and application, as well as other sources of phosphorous, (i.e. naturally occurring), the soil structure for determination of the leaching and runoff potentials of the chemicals, and the general land use (industrial, residential, or agricultural). Unfortunately, actual phosphorous and nitrogen data is not available at the county level for the state of Michigan. Therefore, the phosphorous contents of manure will be used as an indication of the phosphorous problems resulting from livestock production in Michigan (Map K.4, Appendix K).

Additionally, the Economic Research Service's database includes "Potential Nitrogen Runoff" (Map K.8, Appendix K), which captures the potential damages from

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[18]Eutrophication is the process by which a body of water becomes rich in dissolved nutrients which increase plant growth and, consequently, may cause the lake to become deficient in dissolved oxygen.

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excess crop nitrogen to surface waters.[19] Potential nitrogen runoff as calculated by the Economic Research Service is also high throughout the state when compared to potential nitrogen as a problem for the entire country. The values range from 45 to 85 (on a range from 0 = no problem, 100 = extreme problem), indicating that all areas in Michigan have a potential for nitrogen runoff even without adding nitrogen from manure into the calculation.

The inspection of the relevant maps (Map F.3, Appendix F, Map K.2 and K.5, Appendix K) indicate that Potential Nitrogen Runoff may not accurately reflect the Nitrogen runoff problems in the state of Michigan, primarily because animal manure, fruit and vegetable production or sugarbeets were not taken into consideration in the calculation of nitrogen runoff. Excess nitrogen was based on corn, wheat, and cotton crop requirements for growing at each sample point. The equation does not account for which variable contributes the most to the resulting value of potential nitrogen runoff. The excess nitrogen calculations were based on three primary factors: (1) the propensity of the soils to leach nitrates (and pesticides), (2) the amount and timing of rainfall which is required to carry the nitrates through the soil and to the groundwater, and (3) the extent of chemical use.

Only considering the production of crops, the highest potential nitrogen runoff does not match the counties with the highest production of crops in the state. As ERS calculated the variable, potential nitrogen runoff depends on the amount of residual nitrogen above crop requirements, as well as the infiltration and water-holding capacity

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of the soils. The infiltration and water holding capacity of the soil may be the dominating factor in the resulting calculation such that Potential Nitrogen Runoff may show up in counties where crop production is low but the water holding capacity is even lower. Additionally, if animal manure was taken into consideration in the estimation of high nitrogen runoff, the areas which would show the highest potential problems would be the Thumb area which both have large numbers of animals (mostly cattle), and the highest production of crop acreage. Thus, the two variables could potentially complement each other in determining the total nitrogen problems in the state. For example the extent of nitrogen runoff on the west side of the state can be explained by the fruit production, the south west counties use large amounts of commercial fertilizers, and the thumb area is engaged in heavy livestock production.

2.2.5 Sediment Delivery

Sediment Delivery is a variable included in the section of surface water because sediments contributing to water pollution carry soils into lakes and streams, and more importantly, carry with them nutrients and pesticides. The variable originated at the Economic Research Service in the form of Potential Sediment Delivery. Sediment delivery was calculated by the Economic Research Service based on the distance to water, measured from every NRI sample point, and the amount and slope of intervening land uses.[20] The counties with the most potential for sediment delivery problem coincide with those that have at least some slope, crop production as well as many lakes and rivers

[20]The amount and average slope of intervening land uses were proxied by the acreage and average slope of cropland, pasture, and forest land in each NRI polygon.

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(Maps G.3 and G.4, Appendix G). Although the Upper Peninsula has higher slopes and more sandy soils (the composition of soils was not taken into consideration in the equation by the Economic Research Service), it also consists primarily of forests, which was not given as much weight in the calculation of potential sediment delivery as cropland. The exception was Dickinson county, which has very few lakes, a medium number of rivers, and low slopes, and it does have a considerable amount of cropland, which contributes to potential sediment delivery into surface water bodies.

2.2.6 The Potential for Filter Strips

A data set from Lee and Lovejoy (1994) contains the characteristics of land area suitability for riparian buffers to control agricultural nonpoint pollution through a GIS approach. The authors conclude that "the effectiveness of filter strips to reduce agricultural cropland non-point source pollution will depend on the slope of the cropland" (Lee and Lovejoy, 1994, p.14), that is "[p]revious research has shown that filter strip efficiency in reducing sediment and sediment attached nutrients and pesticides increases as slopes decrease." The results of the analysis reveal that 82 percent of the two million acres of US cropland lies in regions with slopes between 0 and 2 percent. However, it was determined that 94 percent of agricultural cropland available for filter strips falls within the range of 0 to 4 percent of sloped land, which would benefit from filterstrips.

In addition, in the slope category from 0 to 2 percent, most of the crop and pasture land is located in the Thumb region of Michigan, and the south east counties of the state. The latter counties include Washtenaw, Jackson, Calhoun, St. Joseph, Hillsdale, L

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Hillsdale, Lenawee, and Monroe. All these counties, except St. Joseph, are also included as counties which display a high potential for sediment delivery into surface waters in the discussion above. These findings are also important for the problem of animal manure in the state. The same counties (and more) contain a large number of animal units, (i.e. the Thumb counties, the south east counties and some of the central and western counties). Manure problem is relevant for filter strips because filterstrips can reduce the runoff problems from manure sources.

Therefore, the results show that the use of filterstrips in relatively flat regions may be effective in reducing agricultural nonpoint pollution to surface waters in some areas in the United States. As an illustration for the extent of the spatial data, the Lee and Lovejoy arbitrarily chose Michigan. The Michigan data includes slopes in the above mentioned categories, the acres of cropland, "other agricultural land," wetlands, and forests. The acreage is then divided into acres that include streams and acres that include no streams. The results were mapped using Atlas GIS. Only the acres of crop land with streams present on the cropland are included. (Map G.5, G.5.1 through G.5.5.6, Appendix G). Michigan has approximately 50,000 acres of cropland/pasture which coincide with stream locations. In general, most of the counties in the southern lower peninsula of Michigan contain streams and have a large amount of cropland with slopes from 0 to 4 percent. The data provided by Lee and Lovejoy can be used for other potential nonpoint source pollution problems, such as potential manure runoff.

Additionally, the Economic Research Service data includes a variable of "potential for filter strips." The variable identifies sites for riparian filter strips which will intercept sediment and nutrient runoff in areas bordering streams. NRI sample points were

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points were identified which represent fields within 100 feet of water bodies as having a potential for filter strips. The resulting national map reveals scattered areas as having a high potential for filter strips. The study by Lee and Lovejoy (1995) for the potential for filterstrips differs from the Economic Research calculation for filterstrips in that Lee and Lovejoy calculated elevation using a 1:250,000 level scale, which implies that the minimum pixel (data resolution) as approximately 100 by 100 meter square areas, while the Economic Research Service used NRI sample points.

For the Michigan Economic Research Service data the areas with potential for filterstrips are located in the Thumb area and the Saginaw Bay, as well as the south east counties of Monroe and Lenawee, the southern counties of Cass and St. Joseph, southwest region, and some counties in the center of the southern Lower Peninsula. Additionally, the fruit producing counties on the western coast can be classified as having a relatively high potential for filter strips. In the Upper Peninsula, Menomenee county and the far western counties of Ontenagon and Gogebic are available for filter strips, although only Menomenee county has significant agricultural production.

2.2.7 Nitrate Leaching

Nitrates from fertilizers, pesticides, and manure are common groundwater contaminants originating from agricultural production. The extent of contamination and the rate of infiltration of the chemicals into the groundwater depend greatly on the characteristics of the soils. Soils which are relatively impermeable, such as clay, provide some protection to groundwater from surface contamination, while more permeable soils, such as sar

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such as sand and gravel, allow contaminants to flow into the groundwater relatively quickly.

No data as to actual groundwater contamination by agro-chemicals such as pesticides and nitrates is available. Therefore, potential data on potential nitrate and pesticide leaching from the Economic Research Service are used to proxy groundwater quality issues, which excludes data for animal manure.

The Economic Research Service calculations for potential nitrate leaching were based on the Groundwater Vulnerability Index (Kellogg, et al., 1992) which include excess nitrogen calculations, precipitation, and soil leaching potential. No information on precipitation and soil leaching class are available and an equation was not provided in the Economic Research Service publication. However, the groundwater vulnerability index for nitrate leaching was based on work by Williams and Goss (1992), and excess nitrogen calculations were developed by Wen Huang (1992) and reference was made to those calculations.

The data provided by Economic Research Service indicates that potential nitrate leaching is a problem for Michigan when compared to the U.S. as a whole (Map L.3, Appendix L). Compared to the national index the data for Michigan ranges from 0 to 5.1, while the national data ranges from 0 to 100. The national data range normalized, while the Michigan data was extracted without normalization. The map indicates the problem areas are in the Thumb area, some counties on the west side of the state and especially in the southwest counties (Map L.1, Appendix L). The unweighted Economic Research Service values indicate that the highest potential for nitrate leaching occurs in the upper peninsula and the entire western part of the lower peninsula. The counties with

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the lowest potential problems are Antrim county (northern lower peninsula), Mecosta, Kent, and Ottawa counties (west central part), and Berrien county in the far southwest corner of the state, as well as Wayne county in the southeast.

Most nitrogen runoff occurs in the Upper Peninsula; at least parts of the counties show slow to moderate soil permeability and some crop and vegetable production. According to the data, the only counties which show the highest potential for nitrogen runoff are Houghton and Iron counties, and Baraga county in the Upper Peninsula. The north western part of the lower peninsula also exhibits an extremely high potential for nitrogen runoff, however, the soils are highly permeable with a low porosity. Maps from the Status and Potential of Michigan Agriculture (the Status of Michigan Agriculture and Its Resource Base, 1992) show the topography of Michigan (Map G.1, Appendix G) and the Soil Permeability for Michigan (Map G.2, Appendix G).

However, since runoff and leaching potentials tends to be inversely related, approximately the opposite results of nitrogen runoff potential would be expected when taking into account the soil structure in the counties. Those areas which have a highly permeable soil should display a high potential for nitrogen leaching, which they do. The data shows that the highest potential nitrate leaching is found in Muskegon county on the central western side, Allegan and Barry counties in the west, as well as Cass and St. Joseph counties on the southwest part of the state. These counties have highly permeable soils but also have at least parts of the soil as only moderately permeable (Lusch and Rader, 1992). Also extremely high potential is found in Huron and Tuscola counties (Thumb area) which are classified as slowly permeable and mostly moderately permeable. Some of the counties which have most of the acres in crop production display the

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display the highest potential for potential nitrogen leaching (particularly the Thumb region and the south east of the state), which, in part, can also explain the distribution of high nitrate leaching.

2.2.8 Pesticide Leaching

Chemical-specific properties of pesticides influence the vulnerability to leaching, runoff, and the volatilization into the atmosphere. Pesticides which dissolve readily in water are considered to be highly soluble, promoting the leaching of the chemicals into the groundwater as well as runoff to surface waters. Pesticides with high vapor pressures are more likely to vaporize into the atmosphere during applications to fields, while other pesticides are easily sorbed to soils, promoting runoff. Pesticides which are subject to sorption, particularly to clays and other organic matter, do not readily leach through the soil, but may be discharged into surface waters through runoff (National Research Council, 1993, p. 317). Once a pesticide reaches the soil, its potential damage to the environment is largely dependent on the sorption and persistence of the chemical. Sorption is commonly measured by a sorption coefficient based on the organic carbon (matter) content of the soil. Persistence of pesticides can be estimated by use of the half-life, which is the time it takes for 50 percent of the chemical to be degraded. Chemicals with low sorption coefficients are likely to leach into the groundwater, while pesticides with long half-lives can be persistent.[21]

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[21] A study conducted by Rao and Hornsby (1989) classifies pesticides into three categories of persistence: nonpersistent if the pesticide has a half-life of 30 days or less, moderately persistent for pesticides with half-lives between 30 and 100 days, and persistent for half-lives

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High solubility of the chemicals promotes the leaching potential, as does a low absorption rate and a high persistence of the chemical. Additionally, the soil characteristics which promote the leaching of chemicals include a coarse soil texture for high permeability, low organic matter content, for a low chemical degradation rate, and the presence of macropores.[22] The sites which promote pesticide leaching are low temperature soils, shallow depth to the groundwater, and a wet climate or regions with heavy irrigation.

Soluble pesticides may leach through certain soil types into the groundwater. Although no actual pesticide leaching rates are available, the Economic Research Service provides a data set on potential pesticide leaching. The "Groundwater Vulnerability Index" for Pesticides is a function of soil leaching potential, pesticide leaching potential, precipitation, and chemical use (type of chemical, rather than amounts). Chemical use at each NRI sample point was inferred on the basis of crops grown using chemical input (fungicides and herbicides) use data by crop and state developed by Gianessi and Puffer (1992, 1990) and used by the Economic Research Service for Potential Pesticide Leaching. The map for Potential Pesticide Leaching can be found in Appendix L, map L.2.

The soil structure of Michigan can also give certain indications as to which regions of the state are more vulnerable to pesticide leaching than others. The western

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of over 100 days.

[22] Macropores are formed by earthworms and decayed root systems. Under certain conditions, water and chemicals in the dissolved and particulate states tend to move through the macropores and reach the groundwater table in a shorter time (National Research Council, 1993, p.320).

part of the state consists mostly of sandy soils which promotes the leaching of contaminants into groundwater. Additionally, fruit and vegetable production, which uses the majority of pesticides, is primarily located along the western coastal counties. Therefore, the coastal region of the state would be expected to show the highest potential to pesticide leaching. Indeed, the map, produced from the Economic Research Service data, indicates that the most vulnerable counties are located along the western coast.

2.2.9 Soil Quality

Soil quality losses increase both environmental and agricultural production costs and may have direct effects on the sustainability of a productive agricultural system. Soil degradation results from compaction, salinization, acidification, and losses in biological activity, which can increase the vulnerability of soils to erosion and can worsen the water quality problems associated with sedimentation. Soil degradation from erosion can lead directly to water quality problems through sediment and chemical delivery to surface waters (National Research Council, 1993, p. 196). Additionally, soil degradation leads to a reduction in the soils ability to regulate water flow as well as its capacity to buffer nutrients, pesticides, and other inputs, which in turn accelerates the degradation of surface and groundwater (National Research Council, 1993, p. 198).

Soil quality is determined by a variety of factors, including the nutrient availability in soils, the content of organic matter, the texture, structure, and acidity of the soil and its water-holding capacity, and the rooting depth of the soil. Any estimation of soil productivity loss should ideally take into consideration the profile of the soils. One set of data was provided by Economic Research Service as potential Soil

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Productivity Loss, and Windblown Dust, relating to soil erosion concerns. This data set falls short of measuring soil quality, relying instead on topsoil depth, potential erosion from water or wind, soil degradation, and soil-specific productivity, however, there is no national data sets on soil quality readily available.

2.2.10 Potential Soil Productivity Loss

Potential soil productivity loss was developed by Economic Research Service in order to capture the economic effects of the soil erosion problem associated with agricultural production in each county because soil erosion can reduce the productivity of the soil and pollute the environment. This variable is on a county basis for Michigan, and it represents the relative economic value of different soils. For example, thinner soils with high erosion rates have fewer years of productivity remaining than thicker soils with the same erosion rates.

Usually, the higher the erosion rates, the higher will be the potential soil productivity loss, depending on the depth of the soil. Additionally, a higher productivity loss would be expected in areas of high crop production since it cannot be assumed that all farms keep the fields under a permanent vegetative cover to prevent erosion or conduct other practices which prevent erosion. The southern part of the Lower Peninsula is generally emphasized as having a high potential for soil productivity loss, with a particular focus on the south and southwest corner of the state, all of which have a relatively high acreage of crops in the counties.

The potential soil productivity loss was calculated by the Economic Research Service as an alternative to "T" values, which are the calculated soil loss tolerance factors used by th

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used by the USDA to determine CRP and conservation compliance eligibility.[23] However, the resulting measure does not accurately reflect the actual value of the soil lost to erosion. In effect, erosion occurring in regions which are not used for any economic purposes (agricultural production, industrial or residential development) have less economic value than prime agricultural land or land in prime urban areas. The weighing of the potential soil productivity loss by dryland cash rent reflects the on-farm economic loss that accompanies the loss in soils.

In Michigan, the loss of soil productivity in the prime land areas of the Saginaw Bay area will be economically more damaging to the farm's economic future than soil productivity loss in areas where no agricultural production takes place; for example in parts of the Upper Peninsula. The difference between weighted and unweighted potential soil productivity loss can be observed in Appendix J, maps J.1 and J.2 The soils in the thumb region of the state, and the regions in the south eastern counties of Lenawee and Hillsdale, as well as the south western counties of Ottawa, Kent, Van Buren, Cass and Berrien are among the most "valuable" soils. Almost none of the counties in the northern lower peninsula and the upper peninsula are shaded. Comparing this map with the unweighted map reveals that erosion is a problem in most of the regions in Michigan. The Upper Peninsula's Menomenee and Dickinson counties, and most of the counties in the southern lower state display erosion problems.[24]

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[23]T-Values represent the tolerable soil loss. It is defined as the maximum rate of annual soil loss occurring which would still permit a high level of crop productivity (Strohbehn, 1986, p. 17).

[24]It needs to be noted that, according to the Economic Research Service's data, soil productivity loss is generally not a problem for Michigan compared to other areas in the

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A more accurate and complete estimate of soil productivity loss should have included indicators additional to soil erosion, soil bulk density, and soil depth, such as water holding capacity, an adjustment for permeability, and the acidity (pH) of the soil. The highest value soils based on cash rents are located in the southern parts of the lower peninsula, which is consistent with the adjusted potential soil productivity loss map (Map J.2, Appendix J). The potential soil productivity loss (J.2) appears to displays a reasonable measure of the problems of erosion due to agricultural production in Michigan.

2.2.11 Potential Windblown Dust

Potential windblown dust reflects the potential for off-site air quality damage that is associated with wind erosion. As expected, Michigan is not of primary concern with regard to wind erosion as compared to other parts of the country. The values for windblown dust for the counties in Michigan are distributed from 0 to 3 on the national 0 to 100 index (Map J.3, Appendix J). Although an exact definition for this variable is not available, it represents wind erosion at each NRI sample site. This variable is also weighted by county population which reflects the "potential pool of damages from health, cleanup, and maintenance expenditures associated with wind-borne dust" (Heimlich, draft paper, 1994, p. 20). For this study, the unweighted data for Potential Windblown Dust was used, since it is clear where the heavily urban centers are located.

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country. The problem areas in the U.S. are more concentrated among others in states such as Texas, Montana, South Dakota, Colorado.

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2.2.12 Introduction of Wildlife Habitat

Historically, the conversion of grass land to federal commodity program crops greatly influenced the habitat of wildlife species. Although the federal government has been paying farmers to retire crops through annual set-aside programs, taking land out of production does not necessarily imply more wildlife habitat. In fact, annual retirement programs have the potential to actually harm wildlife when not managed adequately. Farmers have the flexibility to retire the least profitable land and to retire different acres from one year to the next for the annual set-aside program, which does not guarantee an improvement in wildlife habitat. Furthermore, studies show that the set-aside acres reduced the amount of safe nesting grounds for some birds by eliminating the small grain crops which would normally have been grown (Berner, 1994, p. 3).

Although an average of nearly 40 million acres (one tenth of all cropland) is idled annually, wildlife populations "have declined to tragically low levels" (Berner, 1994, p. 1). Grassland songbird populations in Illinois declined over 90 percent between 1958 and 1978; during the same time pheasant, cottontail, and bobwhite populations declined 60, 50, and 48 percent; While over 3 million acres were retired annually between 1960 and 1972 in Minnesota, the pheasant population declined 80 percent (Berner, 1994, p. 1).

Few animal species have the ability for long-term survival on heavily cropped areas. While it is difficult to assess the status of the wildlife habitat, the Michigan Natural Features Inventory, Michigan Department of Natural Resources, Wildlife Division. has developed a database to evaluate the diversity of species in Michigan. The database consists of information regarding the status and distribution of rare and endangered plant and animal species, as well as natural communities, in the state of

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Michigan. Specifically, the location, numbers and condition of species is recorded and indexed by location (county, township, latitude/longitude, watershed), land ownership, current land management, rarity, and species name in order to provide flexibility of referencing and reporting data. The data is gathered through an international network of scientists, land managers, and conservation specialists in the United States, Latin America, and the Caribbean.

Initially, information regarding plant or animal life are gathered from scientific literature, individuals, and museums to identify areas which need immediate attention. Field inventories are coordinated to establish each species' location, numbers, and vulnerability. Species are then ranked according to their rarity. The ranking procedure is based on a global, national, and state rarity index.

For the purpose of this study, species ranking data for Michigan counties was used that was based on a global level. The global ranking was selected based on the assumption that a state ranking may not adequately represent the full extent of threatened and endangered species. For example, a species may be considered rare in the state of Michigan, even though it may be abundant on a global and national level.

The ranks are established on a numeric rank (G1 through G5) of relative risk of extinction based primarily on the number of occurrences of the species globally, and were subsequently mapped usin GIS (Map M.3, Appendix M).

G1 = Critically imperiled globally due to extreme rarity or due to some factor(s) making it especially vulnerable to extinction. Typically 5 or fewer occurrences or very few remaining individuals or acres.

G2 = Imperiled globally because of rarity or because of some factor(s) making it very vulnerable to extinction throughout its range. 6 to 20 occurrences or few remaining individuals or acres.

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G3 = Either very rare and local throughout its range or found locally (even abundantly in some of its locations) in a restricted range or because of other factor(s) making it vulnerable to extinction throughout its range. 21 to 100 occurrences throughout its range.

G4 = Widespread, abundant, and apparently secure globally, though it may be quite rare in parts of its range, especially in the periphery, causing long term concern for the species. Usually more than 100 occurrences.

G5 = Demonstrably widespread, abundant, and secure globally, though it may be quite rare in parts of its range, especially in the periphery.

The data for threatened and endangered plant and animal species were used in addition to the data set provided by the Economic Research Service on the potential for wildlife habitat improvement. It will become clear that the two data sets are quite different in their distribution of endangered species and the potential for wildlife habitat improvement potential.

2.2.13 Potential Wildlife Habitat Improvement

Potential Wildlife Habitat Improvement was included from the Economic Research Service data set to proxy the potential damages to wildlife from agricultural production. "The quality of wildlife habitat depends on the structure of [the] vegetative cover at each [sample] site and the diversity of covers on surrounding sites. It measures general (not species-specific) changes in the habitat structure at the sample point, primarily going from cropland to grass cover, and the diversity of land uses around the sample point" (Heimlich, 1994). The more intensive the existing crop production system, and the

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and the less monotonic the surrounding land use pattern, the more vulnerable is the wildlife habitat in that region.

The Potential for Wildlife Habitat Improvement can be used as a proxy for environmental impacts of agricultural practices. Wildlife frequently is driven from suitable habitat by agricultural development and agricultural production. Wildlife habitat is measured as a general change in the structure of the habitat, rather than as a species-specific measure (Map M.1, Appendix M). Particularly, the approach taken by Economic Research Service describes wildlife as a series of data layers each describing different types of vegetation. Six data layers of habitat were identified: water surface, terrestrial subsurface, understory, shrub midstory, tree bole, and tree canopy. It is assumed that areas with more layers are generally more capable of supporting a greater diversity of species due to the larger number of available habitats.

Wildlife habitat is a potential problems essentially throughout the entire state of Michigan.[25] The areas with the highest potential for improvement include the southeast of the state, as well as the center of the Upper Peninsula consisting of Dickinson, Menominee, and Marquette counties. This result is to be expected given the distribution of counties which predominantly produce crops, namely the counties in the east and southeast of the state. Additionally, the southern half of the Lower Peninsula is more urbanized, contributing to the absence of species.

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[25]For comparison, the national map is included in Appendix M, Map M.4

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2.3 CRP and Commodity Program Payments

The data for CRP and Commodity Program payments were provided by the Environmental Working Group, a nonprofit organization, located in Washington, D.C. The correlation between the potential environmental problems and the payments received by farmers in Michigan will be used to meet the objective of this study, namely the examination of CRP and commodity program payments' influence on agro-environmental problems. Specifically, the location of the CRP and commodity program payments should provide evidence that the federal programs do not match the counties with potential agro-environmental problems, such as soil erosion prevention, surface and groundwater contamination problems, and wildlife habitat destruction. The database on CRP payments consist of the following county level variables:

1. Number of contracts
2. Total enrolled acres
3. Cropland base acres
4. Non-base acres
5. Total value of contracts
6. Average value of contracts
7. CRP payments for 1991
8. CRP as a percent of commodity program payments
9. Reduction in Annual Payments as Contracts Expire forecast from 1996 to the year 2000

For the purpose of this study, the total payments for 1991 was extracted from the database and mapped (Map H.1, Appendix H). The majority of CRP payments were distributed in the Thumb area and the southern parts of the state. As expected, the payments are consistent with the regions of crop and livestock production. However, a comparison of the maps of CRP payments with potential environmental problems reveals some differences. For example, Potential Soil Productivity Loss counties is only partly consistent with high CRP payments counties. Specifically, the southern counties of the state display potential problems and receive CRP payments. However, the regions in the Upper Peninsula do not receive CRP payments but display a large potential for soil productivity loss. Chapter 4 will examine this comparison in more detail.

Commodity Program payments were also provided by the Environmental Working Group, a nonprofit organization, Washington, DC. Specifically, the total amount spent on farms in 1992 consists of the following variables:

1. Loan Deficiency
2. Feed Grain Deficiency Payments and Barley Assessment Deficiency Payments
3. Wheat Deficiency Payments
4. National Wool Act Payments
5. Dairy Termination Program Payments
6. Forestry Incentive
7. Waterbank
8. Extended Farm Storage
9. Extended Warehouse Storage
10. Livestock Emergency Assistance
11. Interest Penalty Payments
12. Milk Marketing Fee
13. Market Gains

In general, federal commodity programs were created to create a "buffer" for farmers from market price fluctuations. Three main programs are used to obtain the goals of 1.) indirect price support, 2.) direct payment to farmers and 3.) supply management. The following discussion is based on the description of the above components which make up the commodity programs. The explanation for each component of federal commodity programs can be found in Appendix E.

Commodity Program Payments are concentrated in the lower half of the Lower Peninsula of Michigan, particularly in the Thumb area, where the majority of livestock and grains are produced. The data for commodity program payment distribution can be found in Appendix H, Map H.2.

2.4 Conclusions

The maps for CRP payments and potential agro-environmental problems will be used in Chapter 4 to identify the locations of counties which match CRP payments and individual agro-environmental problem areas. The agro-environmental problems are combined with CRP payments to determine whether CRP reduces these potential agro-environmental problems. Explanations as to the possible reasons why certain counties show a complete match and other counties do not is also given.

The potential agro-environmental problems are categorized into problem areas such as potential erosion problems, potential surface water problems, potential groundwater problems, and potential wildlife problems. The variables belonging to each group are summed, mapped and combined with CRP payments.

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Chapter 3

Alternative Green Support Programs

3.1 Targeting and the Conservation Reserve Program

Targeting is defined as the selection of critical regions, such as a watershed, critical land within the region, farms, particular environmental problems, or specific practices for agricultural production for the implementation of programs. To the extent that environmental programs have been targeted in the past, most have addressed soil erosion problems. Relatively little has been done to target environmental programs to achieve off-site soil and water quality improvements.

Throughout much of soil conservation policies' history, the programs were targeted to soil erosion problems, exclusive of the magnitude of the problem or the impact on productivity. However, even if targeting were based only at the higher soil erosion rates, such programs would not usually be the most effective way to improve ground and surface water quality, nor wildlife habitat, primarily because the areas with high erosion rates may be different from the areas where other agro-environmental problems are of concern. In fact, targeting highly erosive soil may not even be associated with productivity losses since certain areas may be highly erosive yet have a deep layer of fertile soil. Therefore, these regions may not experience significant productivity losses (Ribaudo, 1986; Batie, 1986).

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Targeting could be based on an entire watershed, as was the case in a study conducted by Park and Sawyer (1983), which targeted soil erosion. This study focused on the special Agricultural Conservation Program (ACP) in the North Fork of the Forked Deer Watershed. The program required that participating farms entered long-term agreements based on whole-farm conservation plans, which were designed to reduce soil erosion on each field for a period of 3 to 10 years. Two questions were addressed by this study: (1) to what extent did the targeted area and long-term agreement increase the cost efficiency of soil erosion control efforts, and (2) how much potential remained within this framework for further increases in cost efficiency? The findings indicate that targeting to a critical watershed can provide significant increases in the cost efficiency of soil erosion control measures and that the potential for additional improvements are possible if targeting is focused on highly erosive soil within a critical watershed.

There are difficulties with programs which target only on the basis of on-farm criteria such as soil productivity losses. Ribaudo (1984) examined off-site damages from agricultural nonpoint-source pollution. Keeping a cost effectiveness objective in mind, Ribaudo concludes that targeting exclusively to on-farm, productivity-related measures may not be desirable. He notes that off-site benefits from agricultural nonpoint-source pollution reduction may be substantial and may even surpass on-farm productivity benefits.

Some previous targeting attempts of the U.S. Department of Agriculture (USDA) have been conducted on the basis of critical resource areas which were believed to evidence severe agro-environmental problems. The Conservation Reserve Program

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(CRP) was initially established with the purpose of reducing agricultural surplus production, raising farm incomes, and reducing soil erosion. It was implemented as a voluntary cropland retirement program, established as part of the Food Security Act of 1985 with the goal of protecting the nation's most erodible and fragile croplands. CRP remains the focus of much of the current USDA natural resource conservation efforts.

Farmers who chose to participate in the CRP are required to implement a conservation plan which must be approved by the local conservation district to place highly erodible land (and, post-1990, lands associated with water quality problems) into vegetative covers (such as grasses, or trees) for 10 to 15 years. Furthermore, farmers must agree not to harvest or graze the land for the duration of the contract, except under specified exceptions. In return, USDA pays farmers an annual rent sufficient to compensate for the retirement of highly erodible land as well as half the cost of establishing a conserving land cover.[26] Under the original 1985 CRP, enrollment was restricted to 25 percent of the cropland in a county to limit damage to a county's economic base in those areas where crops are the primary income source. With a refining of the environmental objectives in the Food, Agriculture, Conservation, and Trade Act of 1990 (FACTA), the CRP program now places more emphasis on ground and surface water quality issues. The result has been partial field enrollments and even stronger incentives to plant trees and grasses.

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[26]The compensation was determined through the submission of bids. The acceptability of those bids may be based on the extent of erosion and the productivity of the land diverted. The payments may be on a cash or in-kind basis but may not exceed $50,000 per year.

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The refining of environmental goals in the 1990 FACTA was achieved with the revision of the bid acceptance procedure. Under the initial 1985 program, bids were accepted based on potential erosion rates, while the new 1990 procedure uses a productivity-based rental rate screen and ranks bids according to the ratio of an environmental benefit index (EBI) to the cost of the contract to government. Only those bids with the highest ratios were accepted. The federal costs were calculated based on the expected rental payments as well as the cost-share payments required if the bid is accepted. The environmental component of the ratio was based on the relative impact on the following environmental goals: (1) improvements in surface and groundwater quality, (2) maintenance of soil productivity, (3) assistance to producers with potential problems implementing conservation compliance plans, (4) acres planted to trees, (5) acres protected within critical water quality problem areas (6) acres protected within specified conservation priority areas.

Although the new 1990 eligibility criteria for CRP enrollment provided a significant improvement in the environmental benefits gained from the initial 1985 CRP program, there were problems regarding the measurements and weighing of the factors defining the environmental benefits. This difficulty existed "especially for practices, such as windbreaks and filter strips that affect areas beyond the immediate location of practice" (Barbarika, Osborne, and Heimlich, 1994).

Nevertheless, the incorporation of the Environmental Benefit Index into the acceptance process after 1990 resulted in an improvement in environmental performance from the post-1985 CRP lands, including (1) an increase in acres enrolled which are planted t

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planted to trees, (2) an increase in erosion reduction (with more erosion reduction due to water, rather than wind), resulting in greater improvements in off-site water-quality, recreational, and wildlife benefits, (3) more emphasis in priority areas, and (4) more land being rejected which sought rents higher than fair market prices (Heimlich and Osborne, 1993). The definition of some terms, such as highly erodible soil, productivity, and the terms of the EBI, all influence the effectiveness of the program in achieving environmental goals.

The expiration of CRP contracts gives rise to concerns regarding loss of conservation, wildlife habitat, and other environmental benefits. Particularly with respect to water quality, potential benefits from the participation in the CRP include lower water treatment costs, lower sediment removal costs, less flood damage, and increased recreational uses (Ribaudo, 1989).

However, due to the voluntary nature of the program and the criteria which determine whether farmers will enroll in the CRP, the effectiveness of the program in achieving environmental quality is questionable. Even though per-acre benefits vary greatly among regions, benefits could be greatly increased if the enrollment could be encouraged in more areas with higher per-acre benefits[27]. For example, the Delta, Appalachia, and the northeast region have the highest per-acre benefits from erosion

[27]The differences in the per-acre benefits imply differences in the demand for water and differences in the severity of agro-environmental problems. The higher the demand for water and water services in the production of agricultural products, the higher the potential per-acre benefits.

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reduction, however, CRP participation is concentrated in the southern plains, northern plains, and mountain regions where benefit ratios are relatively low.[28]

Additionally, the CRP has been expensive. Annual rental payments on contracts average $50 per acre, or $1.8 billion per year. However, these costs must be considered in light of the fact that CRP reduces commodity program costs. If farmers return the currently idled land to commodity crops an increase in acres will result which represents a direct increase in payments from the Commodity Credit Corporation (CCC) (Young and Osborne, 1990). The crops on former CRP land would make it possible for farmers to receive deficiency payments instead of CRP payments, which is a direct expenditure to USDA.

As CRP contracts began to expire in 1995 and annual rental payments are discontinued, there is growing concern as to what is to be done with the land currently enrolled and conservation policies in general. Even though the conservation compliance provision was implemented to provide an incentive for the transition to noncrop uses of enrolled land, it may not be enough to actually keep land from returning to crop production. Heimlich and Osborne (1993) indicate two reasons that CRP land may return to production: (1) farmers enrolled a large number of acres with relatively low erodibility (acres having an erodibility index of less than 8 which are therefore not subject to the conservation compliance, and (2) the USDA lowered the conservation compliance erosion goals from the more rigorous originally proposed T value standards,

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[28] Benefits were estimated with a set of chemical, physical, biological, and economic linkages between soil erosion and water use (Ribaudo, 1989).

which represent the maximum level of soil erosion that will permit a high level of crop productivity to be sustained.

Survey results indicate that almost half of the farmers who stated that they already had plans for their CRP land after contracts expire (Heimlich and Osborne, 1993). Those farmers with plans indicated that half of the land would be returned to crop production, a third would be left for livestock grazing and hay production, and one tenth would be kept in tree or grass cover. However, about 74 percent of the land enrolled in CRP is classified as highly erodible land and is, therefore, subject to the conservation compliance provision (Barbarika, Osborne, and Heimlich, 1994). This classification implies that farmers will be required to implement conservation plans, if the land is to be converted to crop production.

One possibility currently debated would be to include a revised Conservation Reserve Program in the 1995 Farm Bill based on modified enrollment criteria. However, the budgetary and political implications are likely to prohibit a continuation of the CRP in the present form. Given the current budget situation, it is unlikely that environmental protection programs will receive considerable increases in government funding. There is, therefore, a reason to analyze a program which will not only gain the political support of policy makers but also be as cost effective in obtaining environmental quality. This design may be that of a more targeted CRP perhaps as part of a green support program. As discussed in Chapter 1, a green support program would pay producers for implementing and maintaining environmentally protective production practices, rather than a program which is based on the production of crops, as is the case with commodity programs. There are alternatives to targeting based on current CRP participation, for example, targeting could require both CRP participation and significant agro-environmental problems.

3.2 Targeting on the Basis of CRP and the Composite Environmental Vulnerability Index

Targeting on the basis of the Environmental Vulnerability Index (EVI) would target on criteria defined as priority issues. Priority issues would vary by region but could be surface and groundwater quality, wildlife habitat, or soil erosion. The (unweighted) composite index was calculated by summing all potential agro-environmental problems provided by the Economic research Service.

The environmental outcomes of these targeting schemes, as well as their distributional effects (i.e. which of the producers would receive payments due to a retargeted green support program or a redesigned CRP), vary depending on which variables within the criteria are chosen. For example, targeting green payments on the basis of soil erosion will have a different distributional impact than targeting on the basis of groundwater quality variables on a county level.

There could be two criteria for alternative targeting: (1) the targeted counties must already receive CRP payments and (2) the counties must have significant potential agro-environmental problems. The counties which receive little or no CRP payments but demonstrate significant agro-environmental problems would receive green support payments for the implementation of environmentally protecting farming practices.

Targeting based on agro-environmental "hot spots" or on potentials for agro-environmental problems, regardless of participation rates in the commodity programs or in the CRP is likely to benefit groups which do not currently receive commodity payments or CRP payments. This chapter addresses the alternative green support programs such as the implementation of conservation practices. In addition, there are certain considerations with the proposed alternative production practices, including the eligibility criteria, which will be discussed in chapter 4, and budget constraints, possible alternative designs, and enforcement methods, which will be discussed in chapter 5.

There are several alternatives for a green support program that do not require CRP participation, for example targeting on the basis of commodity program payments. However, this alternative will only discussed briefly in Chapter 4.

3.3 Alternative Green Support Programs: Targeting for Specific Environmental Problem Variables

Targeting all agro-environmental problems on the basis of the EVI may not be the best alternative and may be impossible given the current data limitations. Targeting all potential agro-environmental problems involves immense amount of data and knowledge and would result in a program, depending on design, which would possibly cost more than the current CRP. The targeting of all environmental problems may miss certain problems which need to be addressed immediately, but which may not show up on the maps of the summation of all potential environmental problems.

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An alternative to a targeted CRP is a green support programs for an individual agro-environmental problem. In this study, targeting specific agro-environmental problems are Potential Surface and Groundwater Problems, Potential Erosion Problems, Potential Wildlife Habitat Problems (selected from the Economic Research Service data base), Potential Manure Problems (calculated from the Manure Worksheet), and Potential Pesticide Problems in Fruit and Vegetable Production. Each will be addressed separately in Chapter 4. With this alternative, producers would receive green payments if they implement practices which reduce specific agro-environmental problems on their land, or CRP-like payments to idle lands. Specific agro-environmental problems allows a more detailed analysis of the alternative programs. The remainder of this chapter discusses general issues associated with the design of targeted green support programs based on individual agro-environmental problems.

3.4 Alternative Green Payments Based on Potential Erosion Problems

Erosion can affect the soil in the form of wind erosion, water (rainfall) erosion, and uncovered hillside erosion. Rainfall on unprotected soil detaches soil particles from the soil layer and transports the soil downslope. The resulting runoff transfers the soil, which causes additional erosion, and the rain water is also lost for crop production (National Research Council, 1993, p. 339). Runoff can be defined as the excess rainfall which is not absorbed by the soil. Erosion on uncovered hillsides results in rills which cut through the vegetation on the slope and into mud collections at the bottom of the hills (National Research Council, 1993, p.340). In most farming enterprises, the time period critical f

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critical for erosion is the time between harvesting and before the new crop is established. During this time period, the soil is most vulnerable to wind and water resulting in high erosion potential.

Improved agricultural practices, in the form of different conservation tillage methods, could potentially reduce the environmental damages caused by agriculture induced erosion and could form the basis on which green payments would be made. For example, different tillage systems have been compared in terms of their potential to reduce soil erosion and profitability. The effects of improved practices on surface and groundwater quality has been modeled by Crowder and Young (1988) using a field scale computer simulation program. Specifically, soil conserving practices were analyzed in terms of their cost-effectiveness in association with environmental damage. These practices included: (1) permanent vegetative covers, (2) contour tillage, (3) winter cover, (4) reduced-till and no-till, (5) reduced waterway system, and (6) terrace and diversion systems, as well as a combination of these techniques. The results indicate that such management practices as reduced-till or no-till are more effective than structural measures for controlling pollutant losses from agricultural production.

Therefore, conservation tillage is one way to reduce erosion and, subsequently, sediment loading into lakes and streams. There are several conservation tillage systems used in the U.S. Mannering et. al (1987, p. 3-17) has developed a summary of the conservation tillage systems and the description of each system:

(1) <u>No-till or slot planting</u>: the soil is left undisturbed prior to planting. Planting is completed in a narrow seedbed approximately 2 to 8 inches wide.

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(2) Ridge-till: the soil is left undisturbed prior to planting. Approximately one third of the soil surface is tilled prior to planting. Planting is completed on ridges usually 10 to 15 cm higher than row middles.

(3) Strip-till: the soil is left undisturbed prior to planting. Approximately one third of the soil surface is tilled at planting time.

(4) Mulch-till: The total soil surface is disturbed prior to planting.

(5) Reduced-till: reduced-till system consists of any other tillage and planting system which produces 30 percent surface residue cover after planting.

The effects of conservation tillage on soil erosion and runoff can be significant. Laflen, et. al (1990) have developed a study which shows the surface soil cover, soil erosion, and runoff from different wheat tillage systems.

Table 3.1 Effects of Conservation Tillage (after Laflen, et. al, 1990)

Period	System	Cover (%)	Runoff (cm)	Soil Loss (kg/ha)
Fallow after harvest	bare fallow	62	0.9	662
	mulch	91	1.5	803
	no-till	91	0.1	718
Fallow after tillage (left unplanted)	bare fallow	4	3.6	9401
	mulch	92	0.9	208
	no-till	96	0.1	17
Wheat, 10 cm tall	bare fallow	26	3.5	7246
	mulch	38	2.4	2576
	no-till	85	0.5	550
Wheat, 45 cm tall	bare fallow	78	4.3	2094
	mulch	83	2.9	836
	no-till	88	1.6	337

Source: Laflen, et. al, 1990

As Table 2 shows, no till for a field which will be left unplanted is the best alternative in terms of percentage of surface soil cover, potential runoff and soil loss.

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Additionally, a vegetative cover for the non-growing season is also an alternative to reduce soil erosion.

Soil erosion is most likely site (field) specific, thus, a whole farm system may not be the best alternative to reduce erosion on a wide scale. However, these practices could be applied whether an enterprise has current soil erosion problems or not. The factor influencing whether the farmer will implement these conservation practices depends on whether the enterprise is financially capable to adopt erosion prevention measures and on the resulting profitability of the enterprise.

Furthermore, farmer education on the different erosion control measures, the consequences of erosion to surface, groundwater, and wetlands, as well as on available technology may be appropriate. Technical assistance to identify the fields which are in need of erosion control measures is important for the success of an erosion control measure. Reduced erosion is important to keep the surrounding waterways clean of sediments, excessive nutrients and chemicals. The requirements of a system for achieving the goals of soil erosion reduction ideally includes: (1) the definition of eligible land which is in danger of soil loss by erosion, i.e. how much erosion is acceptable, if any. (2) the identification of those farmers who already have implemented erosion control measures such as no till, permanent or winter vegetative covers, buffers around their fields, etc. (3) the provision of the administrative flexibility to "enroll" fields which are subject to soil erosion, (4) the addressing of both water and wind erosion were appropriate, (5) the availability of standardized statewide databases regarding soil erosion, and (6) the development of a standard ranking procedure for predisp

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predisposed land which identifies the severity of soil erosion on specific fields (Roloff, et. al, 1988, p. 99).

Unfortunately, the maps produced for Michigan counties which have a high potential for soil erosion are at too aggregated a scale for this study to determine the fields which are extremely erosion prone. The data was not available on a field level, thus, to design an ideal green support program addressing soil erosion, more detailed information as to the specific fields is needed. Chapter 4 will show county level targeting outcomes, but to actually implement such a program, more specific state-wide data is needed.

If farm level data were available, farmers on erosion prone lands could receive green support payments for the implementation of soil erosion conservation practices. For permanent vegetative covers on highly erodible lands, enterprises could receive compensation for losses incurred because of not growing crops, fruits, and vegetables.

Erosion, in some, but not all, cases, is synonymous to surface water nonpoint pollution problems. The problems to the water bodies results primarily from sediment and chemical deposition due to runoff. The following section briefly describes possible measures to reduce agro-related water quality problems.

3.5 Alternative Green Payment based on Surface Water Problems

Surface - and groundwater problems are related because nitrogen and pesticides could runoff into surface water bodies or could leach into the groundwater and then reach surface water. However, difficulties in data availability means that it does not makes sense t

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sense to combine the two analyses of surface- and groundwater when discussing alternative green support programs. The Economic Research Service distinguishes between Potential Groundwater Problems which they relate to nitrate and pesticide leaching. In contrast, the variables of Potential Surface Water Problems take into account the Potential for Sediment Delivery, Nitrogen Runoff, and the Potential for Filterstrips.

In order to design a green support program for surface water problems, certain issues need to be resolved. First, it is necessary that the potential surface water problems be located.

Green payments based on surface water problems would flow to the farms and counties with most of the surface water contamination potential. Although it is beyond the scope of this study to actually determine which farms are causing the most surface water runoff, an ideal green support program would identify the farms which are found to be the source of off-site surface water runoff. Once this task is accomplished, each farm may be required to develop a plan to, say, reduce the runoff from agricultural activities if they are to receive green support payments. In the case of surface water, it could be necessary to reduce the amount of nitrogen fertilizer applied to fields. The plan could resemble a water quality compliance plan which would perhaps correspond with the conservation compliance program implemented in the 1990 farm bill.[29]. These plans

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[29]The conservation compliance provision requires all farmers who produce on Highly Erodible Land (HEL) to have a conservation system, approved by USDA, on those lands. Violations result in the disqualification from federal programs (Anderson, 1995, p. 190). The conservation compliance provision was implemented to provide an incentive for the transition to noncrop uses of enrolled land, it may not be enough to actually keep land from returning to crop production (Heimlich and Osborne, 1994).

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could include the placements of filterstrips, vegetative covers after winter fertilization, grass borders around the fields, and the like.

Another possibility for a green support program for surface water quality protection is improved nutrient management. The appropriate timing of nitrogen fertilizer can significantly reduce the loss of nitrogen. A recent Economic Research Service study investigated a Mississippi farmer's decision-making regarding the timing of nitrogen fertilizer application in cotton production (Huang, Uri, and Hansen, 1994, in Anderson, 1995). The authors concluded that 1.) Mississippi farmers are indifferent between applying nitrogen fertilizer in the fall or in the spring, 2.) and dividing the fertilizer applications between spring and the growing season appears to be the best strategy to maximize income, 3.) farmers can save significant amounts of fertilizer when applying it only during the growing season with small income losses, 4.) the risk for complying with restricting fertilizer application before planting is relatively small. Although the study was conducted in Mississippi, it may apply at least in part to Michigan farmers. Thus, the requirements for compliance with a water quality plan in terms of the application of fertilizer is viable and would reduce the runoff of nitrogen into surface waters.

Clearly many of the issues discussed with respect to soil erosion apply to surface- and groundwater protection; such as identification of farms and farm fields contributing to the problem and the provision of adequate financial and technical assistance to alleviate much of the sources of the problem. Chapter 4 examines on a county basis the locat

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location of such problems, but an actual green payment program would need to address these complex implementation details.

3.6 Alternative Green Payment Based On Potential Groundwater (Pesticide) Problems: Targeting Fruit, Vegetable and Crop Production

In order to develop an appropriate green support program, it seems also appropriate to examine agro-environmental problems related to groundwater (in this case pesticide and nitrogen leaching). The first alternative green support program concerns pesticide leaching. When mapping fruit and vegetable production, Potential Pesticide Leaching is concentrated on the north western side, the south western side of the state, and some counties in the Upper Peninsula. As discussed in chapter 2, fruit production is essentially concentrated on the western coast counties of Michigan and vegetable production is distributed over the lower part of the state; there is a correlation between fruit and vegetable production and the potential for pesticide leaching.

As discussed in Appendix A, in a study by Kovach, et. al, (1992) a pesticide is likely to leach, i.e. contaminate the groundwater if the sorption coefficient (persistency in the soil) is low, the half-life is high, and the water solubility is high. Additionally, the soil consistency and type, as well as the temperature and moisture of the soil are dependent on the potential for pesticide leaching. All these variation can be found in many parts of Michigan, especially in the fruit producing areas of the state, but also in the vegetable and crop producing areas.

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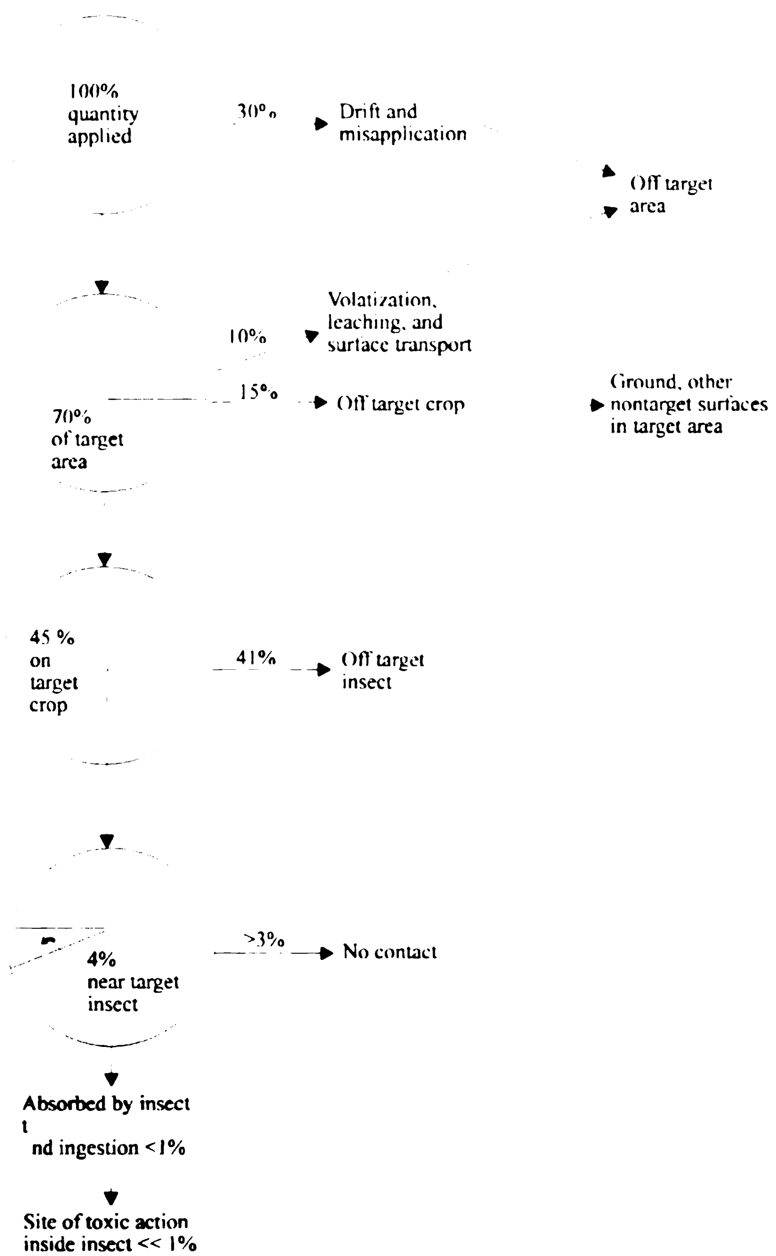
In Figure 3.1, developed by the US Congress, Office of Technology Assessment, the mass balance of a hypothetical aerial foliar spray application of an insecticide is graphed, presenting a comprehensive scheme of the fates of pesticides in the agro-environment. Although the graph is not a complete mass balance for a specific field, it still shows hypothetically where the problems areas lie, i.e. where the effectiveness of pesticide application can be improved. Additionally, the graph indicates that less than 1 percent of the applied insecticide is absorbed by the target pest, while the pesticide loss may be extremely high, indicating that spray-application results in considerable losses through drift and volatization. Additionally, weather condition, especially high winds may acerbate the problem. It can be concluded, that spray application may not be an adequate management practice for an effective pest, and therefore, an effective groundwater management program.

Pesticide losses from soil application, on the other hand, results in much lower pesticide losses. Specifically, Wauchope, (1978, in National Research Council 1993, p. 323) concluded that the portion of pesticides lost is significantly reduced, in some cases (depending on the chemical's composition) as low as 2 to 12 percent, although with highly volatile pesticides it can be as high as 50 to 90 percent. However, generally, seasonal losses of pesticides in surface runoffs and groundwater leaching are in the range of 1 to 5 percent.

In order to better understand the pathways of pesticides applied to fields, the following figure provides and overview of the transport and interaction of the chemicals as they are applied to fruit, vegetable and cropland.

Figure 3.1: Mass Balance Of A Hypothetical Aerial Foliar-Spray Application Of An Insecticide



Source: US Congress, Office of technology Assessment, 1990

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Pesticides which are not taken up by the targeted pest or the crop, and are not volatilized into the air, or degraded in the soil, are subject to movement through the soil and potentially into the groundwater. Although the fate of pesticides once they reach the ground is highly site-specific, Figure 3 still provides a general idea of the interactions between pesticide application and the interaction in the ground.

Figure 3.2 shows the fate and transport of pesticides applied to fields. One of the most important concerns is the contamination of groundwater, although the above figure indicates that the fate of pesticides also affects surface water and air pollution. The effects of pesticide application onto a field depends on the mode of application, although there is interaction regardless of whether ground or aerial application is used.

With ground application, the pesticides are directly applied to the soil surface which temporarily stores the pesticides on the surface. Some uptake by the plant occurs at this point, but also degradation and volatization is a part of the process. Once the pesticide is incorporated within the soil, it is stored in the "Upper-zone, " at which time uptake by the plant, as well as degradation and volatization again occurs. The remaining pesticide is either transferred into water bodies or percolates into the "lower-zone" pesticide storage in which it interacts with other chemicals, soil, water, air, and plants.

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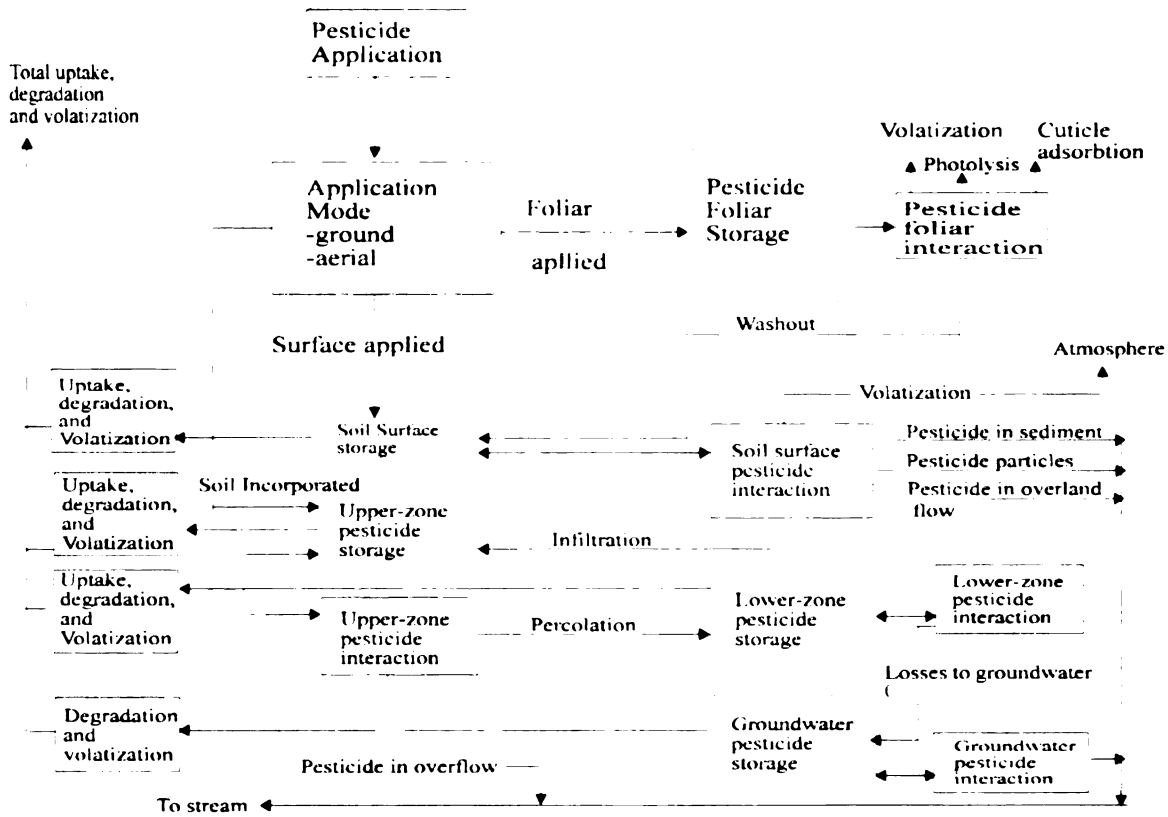
Figure 3.2 Pesticide Transport and Transformation in the Soil-Plant Environment and the Vadose Zone[30]



Source: Cheng. ed., 1990

Under aerial application, the pesticide is directly applied to the vegetation (foliar) and is stored in the plant, after which it is either volatilized, absorbed by the leaf cover, or chemically decomposed by the sun's energy. As with ground application, the remaining pesticide is washed into the soil surface storage where it interacts with the soil, other chemicals, water, air, and plants.. At this point, a number of processes occur. Some of the pesticide is volatilized into the atmosphere, transported in sediment, sorbed

[30]The dotted lines imply storage of the chemicals, while the solid lined represent the function. Additionally, to clarify, the vadose zone is the subsurface above the groundwater where the soil is not yet saturated with water.

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to particles, and carried through overland flow into streams. The remaining pesticide is infiltrated into the upper-zone storage from which it interacts again with soil, other chemicals, water, and the plants. At this point, the pesticide percolates into the lower-zone. Lower-zone interaction involves losses to groundwater in the form of dissolved pesticides and particulates. Once the pesticide reaches the groundwater, it again interacts with the soil, chemicals, and the water. From this point it moves on to streams or is degraded and/or volatilized.

For a pesticide management, Michigan's fruit and vegetable farmers could engage in pesticide pollution reduction methods to receive green support funds. First, the selection of the "right" pesticide and amounts needed is of crucial importance. Obviously, the farmer should select the pesticide which is least harmful for the environment, if a choice between pesticides is available. The "right" pesticide should have the characteristics which include low water solubility, high sorptive capacity, high potential for microbial degradation, and a short half-life. Furthermore, the timing and application methods should be such that they minimize drift and evaporation of the chemical. The possibilities for pesticide application are aerial, ground and through irrigation application. As already discussed and as shown in Figure 3.1, aerial application is potentially the most harmful due to drift and volatization losses of the pesticides. If ground application is not feasible, aerial application should occur when weather conditions are favorable, i. e. when rain is not forcasted in the near future and temperatures are relatively cool. Thus, ground application may be more favorable for certain farms, however, pesticide leaching may then be the primary problem. Irrigation

application is the third application method. This method may be adequate if the groundwater table is relatively deep, otherwise pesticide leaching may become a problem. The property of the soils, the depth to the groundwater table, rainfall, and the slope of the land has to be taken into account when applying the irrigation method.

Additionally, some fields have to be prepared for pesticide application, such as erosion control methods like no-till or conservation tillage systems, cover crops, and filterstrips. Although these methods may reduce the runoff of pesticides, but they may also have a greater potential for pesticide leaching into the groundwater. Due to the problems with the above mentioned application a chemical coupled with a nonchemical pest control method may be the answer to the groundwater problems stemming from pesticide application to fruit, vegetable, and crop fields.

One such system of groundwater and pest control is Integrated Pest Management (IPM).[31] The farmer needs to be informed as to the harm of the pests, the host crops, as well as potential natural predators, such that the enterprise can engage in an ecological pest control technique. Certain guidelines are important in the process of implementing an IPM. It involves the determination of the economic threshold of the pest, i.e. the point at which the cost of pest control is equal to the value of crop loss due to pest damage. Additionally, the farmer must decrease the "equilibrium position of the pest below the economic threshold." The equilibrium position is the average pest density in a field which is determined over some years. The average pest density may be achieved by establishing the pest's natural predators, using pest-resistant plant varieties, as well as

[31]The following discussion is based on the National Research Council, 1993, pp. 332 - 333.

changing the pest's environment through crop rotation. If chemicals must be used, the farmer should use the least environmentally damaging pesticides. Additionally, monitoring the pest population and deciding the optimal time of pesticide application is important in the reduction of groundwater contamination through chemicals. Data needs for such a program also includes monitoring pests on specific crops, as well as the pest biology. Pesticides in groundwater are a symptom resulting from inappropriate or lacking policy.

However, there are several problems with the implementation of an IPM. While IPM can improve the groundwater supply, as well as surface water, pesticide residue in the food supply, etc., the problems fall in the following categories: Technical, financial, educational, institutional, and social. The technical constraints involve the monitoring of the fields, soils, pest resistance for certain cropping systems, and potential predators. However, with adequate technical assistance from federal, state, and/or local agencies, these constraints can probably be overcome. Financial costs may be the most important concern for farmers. While the implementation if IPM may increase the profits in the long-run, short-run losses may be incurred due to crop loss. Farmers generally value pesticides as a risk reduction for crop losses stemming from pests, thus contributing to profits. The implementation of IPM involves a complicated process of methods used, technologies, and behaviors, to which farmers may not be accustomed. Thus, educational problems may become an obstacle to the implementation of IPM since a lack of understanding may result in an inadequate system.

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Institutional constraints apply to all of the green support programs and will be discussed in greater detail in chapter 5. For IPM, the structure for the process can influence the effectiveness of the program such that the agencies involved are not coordinated, i.e. research, education, extension, and corporate coordination is crucial. Social constraints may include growers perception of the technology, communication channels among farmers, as well as the demographic attributes of the producer population all are factors which may inhibit the implementation of IPM (Office of Technological Assessment, US Congress, 1990, p 117).

Despite these constraints, integrated pest management may be an alternative for a green support program, such that farmers would receive green support program funds if they comply with the accepted practices. Failure to do so may result in the termination of the support funds. However, the constraints must be solved through technical assistance and increased funds, as well as educational seminars.

3.7 Alternative Green Payment Based On Manure Production

In the design of a green support program directed at manure problems, it is clear that the program must be planned around the livestock enterprises involved. Obviously, reducing the number of animals in order to improve the manure problems is difficult and maybe uneconomical for an individual problem. A comprehensive manure management plan must be designed since inappropriate manure management is not only a problem for lakes and streams as well as groundwater, it can also harmful to the domestic animals. The harm to livestock is that the manure, if not properly handled, could be spread around th

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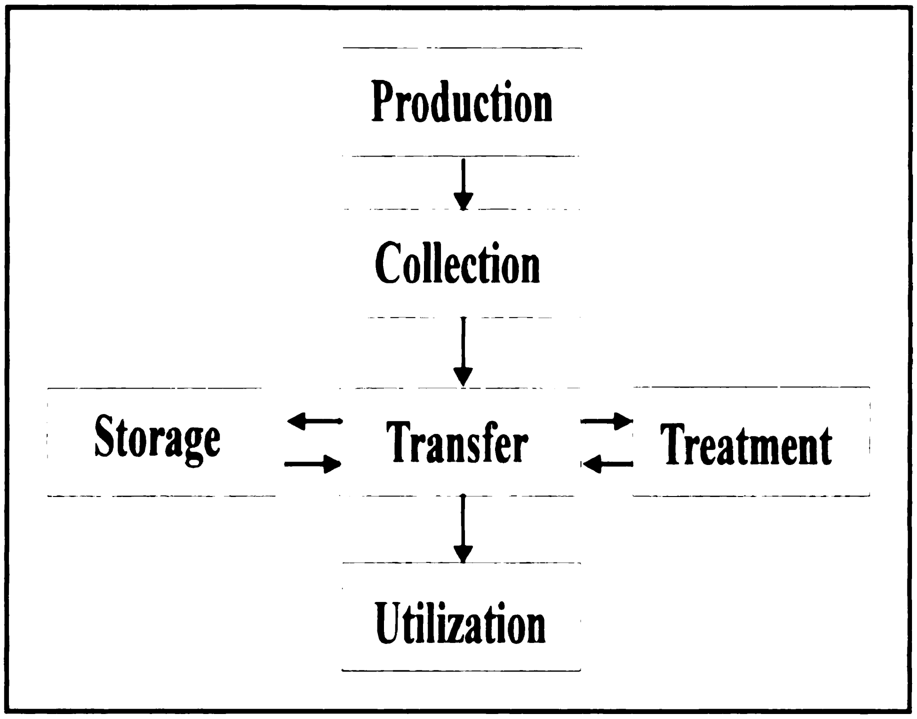
the drinking facilities and could contaminate the drinking water of livestock or could spread parasites.

Similar issues to those discussed before apply to programs targeted to manure. Farmers will need assistance (from federal, state, or local agencies) in most cases to implement a feasible and effective manure management system. Furthermore, the financial status of livestock farms, especially small farms, and the management capabilities need to be addressed by the agencies involved since some small farms may not have the financial resources and equipment to implement the manure management program.

The goal in a manure management plan is to reduce the environmental as well as animal and human risks involved with manure production from livestock operations. In order to achieve this goal, a "total systems approach" is one alternative approach. In this approach, it is assumed that a total systems approach for manure management takes into account all animal wastes from manure production to utilization. As Boyd (1989, p. 56) notes, "in short, it is the management of all the waste, all the time, all the way." He outlined six functions which would encompass the total systems approach: (1) production, (2) collection, (3) storage, (4) treatment, (5) transfer, and (6) utilization. The following figure was adopted from Boyd (p. 56). It shows the six functions of the waste management system and how they relate to each other.

Figure 3.3 Waste Management Functions



Production relates to the waste generated by a livestock enterprise. According to Boyd, "a complete analysis of production includes the kind, consistency, volume, location, and timing of the waste produced." In order to reduce the potential contaminated manure runoff from large livestock operations, waste needs to be kept at a minimum. Runoff could be reduced by restricting the size of the manure holding areas. In cases of large livestock operations, the number of holding areas could be increased but should be kept relatively small in size. Additionally, covering the holding areas may also reduce the possibility of manure escaping the areas. The installation of gutters and diversions to direct uncontaminated water away from the manure and to keep the possibility of runoff into water bodies low. Record keeping on the part of the farmer is crucial to determine the volume, location, and timing of the manure. Assistance to ed

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educate farmers as to the record keeping process and the data which needs to be collected is necessary, if farmers are not familiar with it. Software for record keeping could be used to reduce the efforts.

Collection is concerned with the actual collection of the manure from the position of the manure to the collection point. It is important to plan for the process such that the method of collection, the location of the collection points, and the scheduling of collection is identified. Equally important are the labor requirements for the collection of the manure, the equipment as well as the collection facilities. Installation costs and the effect of the environment needs to be considered.

Storage refers to the temporary containment of the manure waste before application to the fields. "The storage facility of the waste management system is the tool that gives the manager control over the scheduling and timing of the system functions" (Boyd, p. 56). Land application can better be managed, especially when weather and field conditions are suitable for spreading. Also, the timing when nutrient uptake of the crops is best can be determined. The manure storage period has to be determined as well as the management/oversight of the facility must be considered. Additionally, the costs of the storage facility and the requirements for manure volume has to be taken into account.

Treatment is defined by Boyd as any function which reduces the dangers of manure runoff which includes physical, biological, and chemical treatment methods, as well as the pretreatment of the manure such as the removal of solids from the manure. A total systems approach with regard to treatment must include the determination of an examination of the characteristics and the desired characteristics of the manure following treatment. Again, treatment costs, type of the treatment facility, location, and the management costs have to be determined, making technical assistance necessary.

Transfer is concerned with the movement of the manure though the system, i. e. from the production site to the use of the manure. The manure may be required to be transported in several conditions such as in a liquid, solid, or muddy state. Issues of concern are the transportation costs, the method of transportation, the distance to the destination. Furthermore, scheduling, equipment necessary, and the costs of management for the transfer system must be taken into account.

Utilization refers to the recycling of the reusable manure waste and the "reintroduction of nonreusable waste products into the environment" (Boyd, p. 57). Manure in the final stage after treatment can be used as bedding for the animals, as a source of energy, animal feed, mulch, and plant nutrients. Thus, after adequate treatment of the manure, it has the potential to be a marketable good. The recyclable manure can then be spread on fields, which involves the issues of selecting the fields suitable for application, scheduling the application, the design of a distribution system, and deciding on application rates and manure volumes (Boyd, p57).

The maintenance and management of the total systems approach is of crucial importance, since the manure management program is complex and involved. Thus, education as to the procedures and necessary documentation is an important component of a successful green support program.

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Some states already require livestock producers to obtain permits for manure waste management if the livestock enterprise has more than 100 head confined. Michigan at this point does not require permits, however, the Clean Water Act requires permits for over 1,000 head for confined animal feeding operations. Permits may be a logical option for manure handling, especially for smaller enterprises which may not have the volume for a comprehensive system of manure waste management. In such a case, some manure may be stored inappropriately and applied to fields unsupervised and unmanaged such that mishandling may be possible. Permits could be one part of a green support program in addition to manure management practices. Additionally, buffers or vegetative should be constructed around the fields which have been spread with manure so that the runoff from the fields will be minimized.

An ideal green support program could assist targeted livestock operations to adopt the "total systems approach". In addition to the technical assistance, farmers would receive green support payments for the implementation of the manure management system and farmers have the potential to increase revenue when finding a market for the unrecyclable wastes. In chapter 4 the location of manure problems and CRP and commodity program payments will be discussed. Furthermore, explanations as to the reasons why manure is a problem in the counties will be discussed.

3.8 Alternative Green Payments Based Preserving Wildlife Habitat

The following discussion will focus on alternative methods to improve the habitat for wildlife as part of an ideal green support program plan. The composition and quality of a vegetative cover established as a result of specific conservation practices, the management of existing habitat and its maintenance are fundamental issues in the development of a green payment program. However, not all conservation practices benefit species native to grass and or forests due to isolation within landscapes allocated to agricultural production. For example, shelterbelts or windbreaks are conservation practices widely perceived to benefit most wildlife species in the agricultural ecosystem, but they may have "negative impacts on grassland dependent species through increased rates of predation and nest parasitism" (Allen, 1993, p. 3-4).

Wildlife habitat improvement through an alternative green program is ultimately tied to other conservation practices which benefit erosion, surface and groundwater. A green support program could encourage farmers to maintain and create an adequate amount of wildlife habitat to provide for a self-sustaining population of both animal and plant species. Currently, there are problems with certain practices farmers engage in, especially on CRP lands (Allen, 1994, p. 8).

Weed control on endangered lands is one of the primary concerns in the destruction of habitat. Mowing in the animals' reproductive season (prior to July), especially for ground-nesting birds, could result in the destruction of the nests, eggs, and hens. The time and extent of weed control through mowing may have an effect on the next year's early spring nesting due to the decrease in the availability of residual vegetation. To combat the problem, weed control measures such as mowing could be limited to clearly defined harmful species of weed and it should be site-specific, rather than on the entire field scale. Additionally, mowing during the time of the animals'

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reproductive season could be prohibited. Essentially the same recommendation can be made for the practice of haying. Especially on CRP lands, the USDA permitted emergency haying which also substantially reduces the habitat of wildlife. Although not the entire field needs to be prohibited for haying, a certain percentage should be left as a bordering block of cover.

Additionally, a long-term management prospective could be implemented, perhaps in the form of a retirement option for land known to have significant wildlife habitat values. Secondly, a multi-year set-aside with and the emphasis of crop rotation may be another solution to preserve wildlife habitat. Land idling would not only protect wildlife, it would also be beneficial to erosion, as well as surface and groundwater quality. Obviously, conservation practices which can also restore wetlands, especially where wetlands are low in density or are small in size should be of greatest priority over conservation practices which only establish grass cover (Allen, 1993, p.5).

Additionally, a farm-by-farm approach may not be adequate in the case of achieving wildlife habitat improving. Continued maintenance of the land could occur on a regional or county basis in order to maintain regional populations of endangered species, i.e. all agricultural land within a region should be taken into consideration. Fields near shelterbelts, grain fields, riparian zones, and wooded watercourses could be given priority under a green support program.

Furthermore, there are other methods of assisting the implementation of a green support program through technical assistance and management practices, as well as cost-share for farmers in order to commit to wildlife protecting practices.

3.9 Conclusion

From the previous discussion on possible conservation practices for targeted green support programs, it becomes clear that one practice may reduce one agro-environmental problem but may augment another problem. It is common for soil erosion problems to be directly linked to surface and groundwater quality problems and to wildlife habitat. Water quality concerns are almost always connected to wildlife habitat considerations and also reflect on the conditions of the soil. Although is possible to reduce one problem separately, other agro-environmental problems may be missed. A comprehensive soil erosion, surface and groundwater, and habitat may have to be considered jointly, however, the possibility of achieving environmental improvements, with budget concerns in mind, is limited. Perhaps a possibility of targeting agro-environmental problems lies in defining large priority regions such as a watershed, and implementing a comprehensive plan to reduce all agro-environmental problems in that region. A detailed analysis of the agricultural land, water, and biological resources may be necessary to accomplish such a task. When an "agroecosystem" such as a watershed, is the focus for a green support program, on-farm, as well as off-farm environmental conditions are addressed in the same effort (Office of Technology Assessment, 1995, p. 30).

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Chapter 4

Targeting of Agro-Environmental Pollution

The following discussions are addressing the identification of critical environmental areas which contribute to nonpoint-source pollution which are based on generated combination maps. The relationships between commodity and CRP payments and potential agro-environmental problems, on a county basis will be examined.

4.1 Alternative Criteria for CRP Payment Distribution

One green support program option is to continue the Conservation Reserve Program, but to redesign the CRP to target agro-environmental problems. Agro-environmental problems such as potential pesticide and nitrate leaching, runoff rates, or the protection of wildlife habitat, rather than the present general erosion and water quality criteria could be included, the basis on which payments are made to idle lands. The following discussion will be focused on the location of agro-environmental "hot spots," i. e. surface water problems, groundwater problems, erosion problems, wildlife habitat problems, animal manure production, and fruit and vegetable production as they relate to pesticide leaching.

4.2 Location of Conservation Reserve Program and Potential Agro-Environmental Problems

Conservation Reserve payments in 1991 were concentrated in the lower part of the lower peninsula of Michigan.[32] CRP payments are distributed in the counties shown on Table 4.1. Additionally, a map on CRP payments per county can be found in Appendix H, Map H.1.

Not unexpectedly, distribution of CRP payments almost exactly matches the counties with the most crop production in 1992 (see Map F.3, Appendix F). Exceptions to this generalization are Bay and Saginaw counties in the Saginaw Bay area, Shiawassee, Ingham, and Jackson counties, as well as Monroe county in the south east corner of the State, which do not show extreme crop production but receive rather large amounts of CRP. Additionally, a relatively few CRP payments were distributed in the Upper Peninsula, where little crop production occurs (1 to 6 percent of crops are produced in the counties of Menomenee and Delta counties).

Livestock is raised in Ontonagon county, and Chippewa, and vegetable production is distributed in relatively small amounts in the counties of Marquette and Schoolcraft, Iron, Dickinson, and Delta counties. However, livestock are not covered in federal farm programs.

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[32]As a reminder, Crawford and Roscommon counties receive no CRP payments, nor does Oakland and Wayne and most of the Upper Peninsula. However, the map still shows rather insignificant amounts of CRP payments in those counties because rank 1 correspondents to $0 to 2,000, since all data were ranged in quantiles, and zero amounts are not part of the first quantile range. Thus, even those counties which receive no CRP payments have shading.

Table 4.1: CRP Payments per County

	CRP Payments				
	$0	$0 to $10,000	$10,000 to $53,000	$53,000 to $230,000	$230,000 to $1,700,000
County	Alger	Alpena	Alcona	Allegan	Arenac
	Baraga	Benzie	Antrim	Bay	Barry
	Chippewa	Charlevoix	Cheboygan	Berrien	Branch
	Crawford	Delta	Claire	Cass	Clinton
	Gogebic	Dickinson	Genessee	Gladwin	Calhoun
	Keweena	Emmet	Kalamazoo	Iosco	Eaton
	Luce	G.Traverse	Kalkaska	Jackson	Gratiot
	Marquette	Houghton	Leelanau	Kent	Hillsdale
	Oakland	Iron	Mason	Lapeer	Huron
	Ontonagon	Ingham	Missaukee	Livingston	Ionia
	Roscommon	Lake	Monroe	Midland	Isabella
	Schoolcraft	Mackinac	Muskegon	Mecosta	Lenawee
	Wayne	Macomb	Newaygo	Ottawa	Montcalm
		Manistee	Osceola	Saginaw	Sanilac
		Menomene	Presque Isle	St. Claire	Tuscola
		Montmore	Shiawassee	Van Buren	
		Oceana	Wexford	Washtenaw	
		Ogemaw			
		Otsego			
		Oscoda			

4.3 Locations of CRP Payments and the Composite EVI

A targeted Conservation Reserve Program would need to be expanded if the potential agro-environmental concerns in the state of Michigan are to be encompassed within CRP. The following discussion involves a summary of counties with different ranks based on priority of agro-environmental problems and CRP payments. To simplify the explanation of the composite maps as well as for all other potential agro-environmental problem maps and CRP, tables for each potential problems will be included and only counties which display both low CRP payments and high potential for agro-environmental problems will be discussed.

If the proposed new targeting design would continue with the current distribution of CRP payments on a county basis, many of the counties with agro-environmental problems would be missed. Map O.1, Appendix O, shows the combination of all agro-environmental problems (all potential agro-environmental variables added together) overlaid on the 1991 CRP payments, both ranked by priority (1= least potential agro-environmental problems to 4= worst potential agro-environmental problems; 1= least CRP payments to 4= most CRP payments).[33] Additionally, the CRP payments are presented in solid shades while the agro-environmental index is presented in diagonal stripes. The two variables were overlaid to show where CRP payments and agro-environmental problems are both present. Table 4.2 summarizes the findings.

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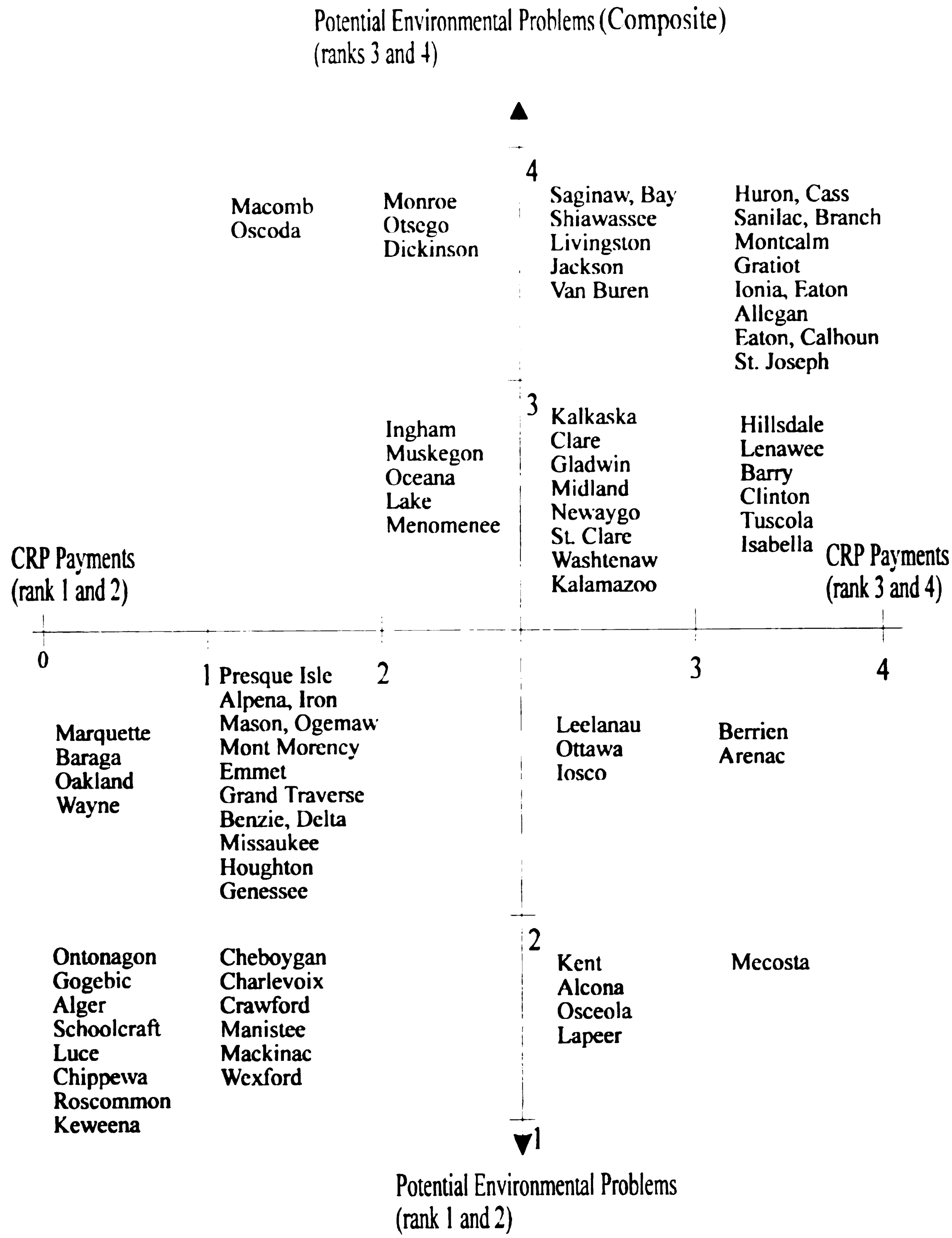
[33]As a reminder, the potential agro-environmental variables were not weighted or normalized

Table 4.2 Composite of all Potential Agro-environmental Problems and CRP Payments



Upper Peninsula: Most of the Upper Peninsula has some potential agro-environmental problems but the counties have little or no CRP payments, the highest ranking with respect to potential agro-environmental problems being Dickinson County (rank 4), mostly due to potential Nitrogen Runoff, potential Sediment Delivery into lakes and streams, potential Wind Erosion, and the potential for Wildlife Habitat Improvement. Menomenee County (rank 3) also is diagonally striped on the map, due to potential Nitrogen Runoff, potential Nitrogen Leaching and Pesticide Leaching, potential Soil Productivity Loss, potential Sediment Delivery, and the potential for Filter strips. Some potential agro-environmental problems (rank 2) exist for Houghton, Baraga, Marquette, and Delta counties which also have low CRP payments.

The remaining counties in the Upper Peninsula have few potential agro-environmental problems with rank 1, while the counties with the most problems (Dickinson and Menomenee counties) engage in crop production (2,200 and 18,050 acres) and raise some livestock.. The main reason for the potential agro-environmental problems in the Upper Peninsula appear to be based in the more rugged topography, the existence of lakes and streams and the extreme soil permeability of the region. The counties in the Upper Peninsula exhibit extremely high soil permeability (> 2 inches per hour), they all have a large number of rivers and lakes, and the topography is steeply sloped. All these land characteristics contribute to potential agro-environmental problems, especially the runoff and leaching problems such as nitrate and pesticide leaching, nitrogen runoff, and erosion.

Lower Peninsula: In the lower Peninsula of Michigan, potential agro-environmental problems are more widespread as shown in map O.1, Appendix O. All counties of Michigan have some potential agro-environmental problems, the highest ranked county (rank 4) being Otsego in the northern half of the state, the Thumb and the Saginaw Bay areas, the central counties of the state, as well as some southern and south western counties. The remaining counties are in the southern half of the Lower Peninsula are rank 3 and 2 with respect to potential agro-environmental problems.

The northern half of the Lower Peninsula has potential agro-environmental problems with counties of rank 2 and 1. Although the Lower Peninsula does not have as many streams as the Upper Peninsula, the counties do exhibit high to moderately permeable soil and the southern and western Lower Peninsula has many lakes (most of which range between 450 to 1000 lakes per county). Additionally, the lower half of Michigan is diverse in agriculture, which also contributes to potential agro-environmental problems.

High CRP Payments and High Potential Agro-Environmental Problems: As Map O.1 shows and as the northeast quadrant of the table shows, less than half of the counties with high ranks of potential agro-environmental problems are matched with those receiving high existing CRP payments (39 percent of the counties). Specifically, the exact match with high CRP payments and high index of all agro-environmental variables with the highest rank of 4 occurs in the part of the Thumb region, a few counties in the center of Michigan, and the southern Ohio border counties. "Fewer CRP payment" counties (rank 3 in the northeast quadrant) with high potential agro-environmental problems are in the Saginaw Bay region, and a few counties in the south. A targeted CRP based on existing participants would appear to be a better match in these counties.

Low CRP Payments and High Potential Agro-Environmental Problems: There are many counties not included within current CRP payment distribution but have potential agro-environmental counties. That is, some counties with high potential agro-environmental problems do not receive CRP funds to idle lands (i.e. the northwest quadrant of the table). Although most of the counties in the upper half of the Lower Peninsula do not contribute to agricultural production to a large extent, most do engage in limited livestock, crop, and vegetable production. Additionally, these counties also demonstrate topographical features favorable for potential agro-environmental problems. The northern half has many lakes and some streams, and the region is highly sloped (called the Northern Upland). If counties would receive payments based on the probable reduction of the agro-environmental problems, these counties would benefit.

Rank 3 with respect to the agro-environmental problem counties which receive the highest CRP payments (rank 4), are counties in the south east of Michigan, in the central region, Tuscola county which is part of the Thumb/Saginaw Bay area, and Isabella county. However, agro-environmental problems and CRP payments with rank 3, meaning that agro-environmental problems are not as severe while CRP payments are between $53,000 and $230,000 from the highest possible $1,700,00, are located in Kalkaska county in the northern part of the state, the central area, as well as St. Claire county in the Thumb, and south of Michigan.

The counties with a rank of 2 in CRP payments but which have a high rank agro-environmental problems are Monroe county in the southeast corner of Michigan, Otsego county in the northern region, and Dickinson in the Upper Peninsula. The next level involves the agro-environmental problem index with a rank of 3 and CRP payments of rank 2. Counties with these ranks include the central part of Michigan, the western coast of the state, and Menomenee in the Upper Peninsula.

Regressing 1991 CRP payments on all counties with the Composite Index of all Potential Environmental Variables shows that the counties with a summation of all potential agro-environmental problems do not match well with the counties receiving CRP payments (see equation E.1, Appendix E). Although the coefficient on the composite variable is positive, indicating that it positively correlates to the counties receiving CRP payments. Thus, the correlation coefficient between the two variables is a positive 0.10, indicating they are positively, but not strongly related.[34]

Critics assert that the current CRP places too much emphasis on on-farm soil erosion problems and falls short of targeting potential off-farm agro-environmental problems. Although the 1990 CRP criteria included water quality criteria, the above discussion shows that the inclusion of water quality did not result in a strong correlation between potential agro-environmental problems and CRP participants. Any attempt to expand the extent of the CRP payment distribution would have to enlarge the criteria to include counties and ideally to certain farmers within the counties whose enterprises contribute to potential agro-environmental problems.

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[34]All regressions were conducted using the econometric software package MicroTSP. The equations can be found in Appendix E.

Of course, targeting on an Environmental Vulnerability Index assumes some weighing as to each component of the EVI. For this study, the weighing on each county was equal. However, in order to better target the potential agro-environmental problems, a more effective means of reducing these problems is to examine the location of the specific potential agro-environmental problem and ultimately the weighing on the Environmental Vulnerability Index could be adjusted based on the damages associated with each problem. These specific agro-environmental problems can include potential surface and groundwater, potential erosion problems, manure production, fruit and vegetable production and the dangers of pesticide leaching, as well as threatened and endangered species and the potential for wildlife habitat improvement. It is also informative to calculate the correlation between the variables. Certain Potential Environmental Variables are better correlated with some variables. For example and perhaps surprisingly, CRP payments at the current level are positively and strongly correlated with manure production. It is also positively but weakly correlated with Potential Pesticide Leaching, and Potential Soil Productivity Loss, while CRP participation at the county level is negatively and very weakly correlated with Potential Nitrogen Runoff, and Potential Wind Erosion.[35]

[35] The correlation matrix can be examined in Appendix E. The scatter plot of CRP payments and potential agro-environmental problems (following the correlation matrix in Appendix E) reveals that many counties with low CRP payments have high environmental problems. Thus, there is no correlation between CRP payments and potential agro-environmental problems.

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4.4 Location of Conservation Reserve Program and Surface Water Problems

The composite of Potential Surface Water was calculated by summing the index numbers of Potential Nitrogen Runoff, Potential Sediment Delivery, and the Potential for Filterstrips (Map N.2, Appendix N). The overlay of CRP payments and surface water variables shows the areas which match and do not match the counties with CRP contracts with the counties with potential surface water problems. Both variables are compared as the other variables above, that is CRP payments and surface water variables are based on priority rankings (Map O.3, appendix O). Table 4.3 summarizes the location of potential surface water problems as they relate to CRP payments. [36]

Assuming actual surface water problems are the same, or close to the same, as potential surface water problems, the counties with CRP payments rankings of 1 and 2 matching with potential surface water problems with rankings of 3 and 4 (i.e. those counties in the northwest quadrant of the Table 4.3) will need to be targeted for green program payments or a redesigned CRP because currently these counties receive few CRP payments.

High CRP Payments and High Potential Surface Water Problems: Counties in the northeast quadrant with high CRP payments and high potential surface water problems should continue to receive either CRP or green support payments. These counties lie primarily in the center and the southwest of Michigan. Specifically, the regions are on the southern border with Ohio, the west, and the center of the Lower Peninsula.

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[36] Variables correlated with each other include Potential Sediment Delivery with the Potential for Filterstrips (0.27), CRP with the Potential for Filterstrips (0.34), and CRP with the Potential for Filterstrips (0.34)

Table 4.3 CRP and Potential Surface Water problems

Potential Environmental Problems (Surface Water) (ranks 3 and 4)

CRP Payments (rank 1 and 2) — CRP Payments (rank 3 and 4)

Potential Environmental Problems (rank 1 and 2)

Potential Environmental Problems	CRP 0–1	CRP 1–2	CRP 2–	CRP –3	CRP 3–4
4	Luce	Dickinson, Monroe	G. Traverse, Lake, Leelanau, Manistee, Menomenee, Oceana, Wexford	Kalkaska, Van Buren	Allegan, Barry, Branch, Cass, Clinton, Isabella, Montcalm, St. Joseph
3	Alger, Keweenaw, Marquette, Oakland	Delta, Houghton, Iron	Benzie, Charlevoix, Emmet, Mason, Muskegon, Otsego	Clare, Jackson, Kalamazoo, Newaygo	Calhoun, Ionia, Huron, Sanilac, Tuscola
2		Alpena, Ingham, Mackinac, Missaukee, Monroe, Montmorency, Ogemaw, Oscoda, Presque Isle		Bay, Gladwin, Livingston, Midland, Osceola, Saginaw, Shiawassee	Arenac, Eaton, Gratiot
1	Chippewa, Crawford, Gogebic, Ontonagon, Schoolcraft, Roscommon, Wayne	Cheboygan, Genesee, Macomb		Alcona, Antrim, Iosco, Kent, Ottawa, Lapeer, St. Claire, Washtenaw	Berrien, Hillsdale, Lenawee, Mecosta

Rank 4 with respect to CRP payment counties combined with rank 3 with respect to potential agro-contamination surface water variable counties are found in the Thumb area, as are counties in the south and central region of the state. Rank 3 with respect to CRP payments matched with rank 4 with respect to Potential Surface Water Problems only consists of Van Buren county, in the south west corner and Kalkaska county in the north of the state. Additionally, rank 3 with respect to both variables include Kalamazoo and Jackson counties in the south, and Newaygo and Claire counties. A CRP program oriented to solve potential surface water problems and that is based on current participants includes these counties appropriately.

High Potential Surface Water Problems and Low CRP Payments: However, there are counties that do not have many CRP payments but these counties should be targeted if the policy goal is to reduce potential surface water problems.

Rank 2 with respect to CRP payments combined with rank 4 with respect to Potential Surface Water Agro-Contamination from agriculture are congregated mainly on the northwestern shore-line of Lake Michigan, as well as Dickinson and Menomenee counties in the Upper Peninsula. A few northern and western counties display the rank 2 with respect to CRP and rank 3 with respect to Potential Surface Water problems.

As shown in Map N.2, CRP with rank 1 and Potential Surface Water Problems with rank 4, Luce county in the Upper Peninsula provides a comparison but does not receive CRP payments. Rank 1 with respect to CRP payments and rank 3 with respect to Potential Surface Water Problems are combined primarily in the Upper Peninsula, with the exception of Oakland.

The variables that comprise the Composite Potential Surface Water Problems Map (N.2, Appendix N), and the correlation coefficients with 1991 CRP payments by county are almost zero with respect to Potential Nitrogen Runoff and are positive. The correlation coefficient for Potential Sediment Delivery is 0.21 and 0.34 for the Potential for Filterstrips. A regression of CRP payments by county against the three surface water variables indicates that the best regressed fit explains only 40 percent of the variation in county CRP payments. Again, the message is clear that existing CRP payments do not match well with a hypothetical green payment program targeted to Potential Surface Water Problems (see equation E.2, Appendix E).

Actual versus potential Data: The use of potential data in lieu of actual data is an unfortunate necessity due to data availability.. However, while state-wide data does not exist on surface water agro-contamination problems, maps do exist on the location of significant water bodies - rivers and lakes. Similarly data exist on cropland location vis-à-vis rivers, streams, and lakes. The location of water bodies is particularly important for the Potential for Filterstrips, which is part of the composite map of Potential Surface Water Problems. The potential for filterstrips are especially high in the Thumb area which has 700 to 1500 miles of rivers (with the exception of Tuscola county which has less than 350 miles of rivers). Additionally, the west and east counties, as well as Menomenee county of the Upper Peninsula exhibit a high Potential for Filterstrips with more than 1500 miles of rivers in the west and 700 to 1000 miles of rivers in the east and in Menomenee county. Furthermore, the distribution of lakes in the Upper Peninsula counties is extremely high, ranging from 450 to 1000 lakes per county. An exception to the extent of lakes is the Thumb region, however, the topography is extremely favorable for potential agricultural surface water problems and, of course, Lake Huron is adjacent to the Thumb. Both the counties in the Upper and Lower Peninsula are highly sloped. The counties in Upper Peninsula lie in the Northern Highlands, while the counties in the Lower Peninsula are the Northern Uplands. (Eichenlaub, 1990). The Thumb counties are in the Thumb Uplands, while the central counties are sloped but not nearly as much as the other counties. Of course, the potential for filterstrips presumed nearby agricultural enterprises. This presumption is more true in the Lower Peninsula than in the Upper Peninsula.

The agricultural production pattern shows that fruit and vegetable production is extensive in the northwest counties and all along the western shoreline. These crops are not included in the CRP but have high pollution potentials. Additionally, animal production is extensive in the central and southern counties. In the Upper Peninsula livestock is raised to a certain extent and vegetable production is also prevalent. Animal production is a problem for animal manure output which, coupled with rainfall and erosion, can cause runoff into the water bodies in the regions. Fruit, vegetable, and crop production is a threat for potential surface water problems since the pesticides and fertilizers applied, coupled with erosion, can potentially pollute the surface water bodies.

For Potential Surface Water Agro-Contamination, the rivers and lakes, as well as commodities produced are also important. As the map shows, the counties in the northeast quadrant of Table 4.3, i. e. the counties receiving the highest amounts of CRP payments with the highest potential for surface water problems, also have some rivers in

those areas. The rivers in most of the counties in the central region are rather insignificant compared to the miles of rivers in the Upper Peninsula, but there is more cropland in this central region.

The northwest quadrant of Table 5 (rank 2 with respect to CRP payments and few (rank 1) or no payments combined with high surface water problems) have few miles of rivers in the north western region in the Lower Peninsula, however, the counties in the Upper Peninsula have extensive miles of rivers, which contributes greatly to nitrogen runoff.

The number of lakes in both the Upper and Lower Peninsula are also a factor for potential surface water problems in terms of nitrogen runoff and erosion problems which encompasses sediment delivery to lakes (Institute of Water Research, 1991). Thus, even though the data on rivers and lakes appears to reinforce the Potential Surface Water problem Map. Potential Surface Water Agro-Contamination is only a potential variable, not an actual level of pollution. Low correlations are not unexpected.

Considering where the potential surface water contamination problems are situated and the general landscapes and slopes, it becomes clear that the existing CRP payments do not have a high correlation with the potential surface water problems. With a targeted green payment program, the counties in the central region of the state should keep the CRP payments or equivalent green support payments but some counties in the north western region and the Upper Peninsula need to be included as well to reduce potential surface water pollution.

4.5 Location of Conservation Reserve Program and Groundwater Problems

Potential Groundwater Problems are defined as a combination of Potential Pesticide Leaching, and Potential Nitrate Leaching variables (Map N.3, Appendix N). The map of the combination of CRP payments and Potential Groundwater Problems (Map O.4, Appendix O) does not show many matches between existing CRP payments and Potential Groundwater Problems. A summary of counties with current CRP payments with respect to Potential Groundwater Problems can be found in Table 4.4.

High CRP Payments and High Potential Groundwater Problems: Establishing the best match first, (rank 4 for both CRP payments and Potential Groundwater Problems), (i.e. the northwest quadrant of Table 6) counties consist of Montcalm in the center of the state, while the remaining matches (high, high) are primarily located in the southern half of Michigan. Rank 4 with respect to CRP payments and rank 3 with respect to Potential Groundwater Problems can be found in the counties of the Thumb region, as well as in the central part of the state, and in the far southeast corner of Michigan.

Rank 3 with respect to CRP payments and rank 4 with respect to Potential Groundwater Problems include the counties of Newaygo in the western part of Michigan, as well as the counties in the southwestern corner of the state, and Kalkaska county in the north. Potential Groundwater Contamination with rank 3 and CRP payments with rank 3 can be observed in only a few counties: Saginaw, Ottawa, Claire and Antrim.

High Potential Groundwater Problems and Low CRP Payments: The rank of 2 with respect to CRP payments combined with rank 4 with respect to Potential Groundwater Problems are located in Dickinson in the Upper Peninsula, Otsego in the

Table 4.4 CRP and Potential Groundwater Problems

Potential Groundwater Problems (rank 3 and 4) ▲

CRP Payments (rank 1 and 2) — CRP Payments (rank 3 and 4)

4		Benzie, Dickinson, Manistee, Lelanau, Otsego, Muskegon, Oceana	Livingston, Kalkaska, Kalamazoo, Newaygo, Van Buren	Allegan, Barry, Branch, Calhoun, Cass, Eaton, Hillsdale, Jackson, Montcalm, St. Joseph
3	Oakland	Grand Traverse, Ingham, Lake, Mason, Menomenee, Monroe	Antrim, Clare, Ottawa, Saginaw	Berrien, Clinton, Gratiot, Huron, Ionia, Isabella, Sanilac, Tuscola
2	Wayne	Charlevoix, Delta, Emmet, Houghton, Macomb, Missaukee, Montmorency, Ogemaw, Wexford	Bay, Gladwin, Kent, Lapeer, Midland, Shiawassee, St. Clare, Washtenaw	Arenac, Lenawee, Mecosta
1	Alger, Baraga, Chippewa, Crawford, Gogebic, Keweenaw, Luce, Marquette, Ontonagon, Roscommon, Schoolcraft	Alpena, Cheboygan, Iron, Genessee, Mackinac, Oscoda, Presque Isle	Alcona, Iosco, Osceola	
	0 1	1 2	2 3	3 4

▼ **(rank 1 and 2)**

northern part of the Lower Peninsula, and on the shore line of Lake Michigan (the northwest quadrant of Table 4.4).

However, rank 1 with respect to CRP payments and rank 4 with respect to Potential Groundwater Contamination appears in Benzie, Dickinson, Muskegon, and Oceana counties. Menomenee county in the Upper Peninsula, Grand Traverse county in the north, Ingham county, Mason county in the west, and Monroe county in the southeastern region of Michigan display a rank of 3 with respect to Potential Groundwater Problems, but have few CRP payments (rank 2).[37]

Actual versus Potential Data: The Composite map of all Groundwater Related Variables (Pesticide and Nitrate Leaching) can be compared with the Soil Permeability map (Map G.2, Appendix G) from the Center for Remote Sensing and the Department of Geography (Lusch and Rader, 1991) and comprised of actual soil data.[38] The map does not take agricultural production into consideration, that is it is entirely a geographic map of soils, whether urban or rural areas, industry or agriculture. However, some similarities

[37]Regressing CRP payments with Potential Pesticide and Nitrate Leaching indicates that the best regressed fit explains only 27 percent of the variation in counties receiving high CRP payments. However, the correlation coefficient for Potential Pesticide Leaching is negligible, and the correlation coefficient for Potential Nitrate Leaching is positive (0.2), both indicate that counties with Potential Pesticide Leaching are not in the same counties with high CRP payments while Potential Nitrate Leaching positively correlates to the counties receiving high CRP payments.

[38]The map is classified by Lusch and Rader into highly permeable (> 2.00 inches per hour [iph], moderately permeable (0.06 to 2.00 iph, and slowly permeable soils (< 0.06 iph). Although the location of surface water is also indicated, it is almost nonexistent on the map due to the elimination of small polygons (smaller than 40 km^2). The map was produced from the USDA Soil Conservation Service's State Soils Geographic Data Base (STATSGO) and the Soils-5 Data Base.

between the Pesticide and Nitrate Leaching map and the soil permeability map are apparent.

The southwestern part of the state and some counties in the center display highly permeably soils. In these counties, most of the production is fruits (in the southwestern counties) and vegetables (in the southwestern shore, in the central regions), crops (Thumb counties, central and southern counties), as well as livestock production particularly in the south western corner of the state and the Thumb region. However, the Thumb counties have primarily low to moderately permeable soils and are heavily engaged in livestock production, which produces manure problems. When weather conditions are unfavorable, (primarily rain) and where there are a few conservation practices implemented for manure management, manure has the potential to leach into the soil and contaminate the groundwater. Additionally the application of fertilizers and pesticides to crops which are grown extensively in the Thumb, can lead to groundwater contamination.

Highly permeable soils are in the northwestern counties, in which fruit and vegetable production dominates. Again, pesticide and fertilizer application combined with highly permeable soils has the potential to severely pollute the groundwater. In the Upper Peninsula, Menomenee and Dickinson counties, both being involved in crop, vegetable, and livestock production combined with highly permeable soils, potentially contribute to groundwater contamination.

As in the discussion of surface water problems, the same conclusion is reached. Although ERS's data on Potential Groundwater Problems only accounts for agriculture, the areas with high Potential Groundwater Problems approximate the regions with high agricultural production. The potential data for Groundwater Contamination approximated the actual problems as evidenced by both agricultural production and permeable soils. In terms of a green support program, some counties with high CRP payments should keep the funds or equivalent counties that should also receive green payments to reduce Potential Groundwater Problems. The remaining counties (in the southwest and southeast quadrant of Table 4.4) should receive no or few CRP or green payments.

4.6 Location of Conservation Reserve Program and Soil Erosion Problems

The Composite map of Soil Erosion Related Variables consists of Soil Productivity Loss and Potential Windblown Dust (wind erosion), both of which were summed to obtain the Composite of Soil Related Variables (Map N.4, Appendix N). As discussed earlier, the CRP is targeted to highly erodible soils amongst other criteria. Therefore, when overlaying the two maps (CRP payments and Soil Erosion) the expectation is that there should be many overlapping counties (Map O.2, Appendix O). However, the Potential variables do not support this expectation (see map and Table 4.5). As Table 4.5 shows, in its northeast quadrant, some counties in the southern half of the Lower Peninsula do support this conclusion; however, many counties which display high Potential Erosion Problems and receive no or few CRP problems. A reason for this outcome may be that CRP bidding was on a national basis. Thus, highly eroding

croplands in other areas might have had more erosion problems relative to Michigan and thus renewed CRP contracts.

Following is a detailed analysis of the matching (rank 4) and non-matching (rank 1) counties.

High CRP Payments and High Potential Erosion Problems: Rank 4 with respect to CRP payments matched with rank 4 with respect to Potential Erosion Problems can be found in several regions: the Thumb, the center, the western shore of Lake Michigan, and the southern border next to Ohio. Rank 3 with respect to Potential Erosion Problems and high CRP payments, the counties are located near the rank 4 counties: Berrien county in the far south east corner of Michigan, Branch county on the southern border, Sanilac in the Thumb and Saginaw Bay Watershed, in the center.

CRP payments of $21,000 to $192,000 (rank 3) with respect to each county combined with rank 4 with respect to erosion are found in the Saginaw Bay Watershed, in the western part of the state, on the western shore line of Lake Michigan, and Antrim county in the north. The CRP payments of rank 4 and Potential Erosion Problems of rank of 3 are located in the south, in the Saginaw Bay Watershed, and in Kalkaska county in the north.

High Potential Erosion Problems and Low CRP Payments: Rank 2 with respect to CRP payments combined with Potential Erosion Problems of rank of 4 (northwest quadrant of Table 4.5) is found in the counties of Dickinson in the Upper Peninsula, in the northern part of the Lower Peninsula, and Monroe county, while rank 3 with respect

Table 4.5 CRP and Potential Erosion Problems

Potential Erosion problems (rank 3 and 4)

CRP Payments (rank 1 and 2) — CRP Payments (rank 3 and 4)

Oakland Schoolcraft Wayne		Dickinson Leelanau Monroe Otsego	Antrim Clare Iosco Newaygo Ottawa Saginaw Van Buren	Allegan Calhoun Cass Gratiot Huron Isabella Lenawee Montcalm St. Joseph
	Macomb	Ingham Mason Menomenee Muskegon Oceana	Bay Jackson Kalkaska Midland Washtenaw	Arenac, Barry Berrien Branch Clinton Mecosta Sanilac
0	1	2		3 — 4
	Benzie Grand Traverse		Alcona Gladwin Kalamazoo Kent Lapeer Livingston Osceola St. Clare Shiawassee	Hillsdale Ionia Tuscola
Alger, Baraga Chippewa Crawford Gogebic Keweenaw Luce, Marquette Ontonagon Roscommon	Alpena Delta Houghton Mackinac Manistee Missaukee Montmorency Genessee Lake, Presque I. Ogemaw Oscoda	Charlevoix Cheboygan Emmet Iron Wexford		Eaton

Vertical axis (Potential Erosion problems): 4, 3, 2, 1

(rank 1 and 2)

to Potential Erosion Problems can be observed primarily in the western shore line counties of Lake Michigan, Ingham in the center, and Menomenee in the Upper Peninsula. The CRP payment rank of 1 is only present with a rank of 4 and 1 with respect to Potential Erosion Problems. Rank 3 can be seen on the map in the south eastern corner.

The topography in the counties is an important consideration, in that slopes increase the magnitude of Potential Erosion Problems. Some of the counties in the south eastern region of Michigan lie in the Thumb Upland which has considerable slopes. However, the central counties are in the Saginaw Lowlands which do not have significant slopes. However, some counties slightly to the west of the Thumb Uplands and the southwestern region are in the relatively high sloped lands, and the counties in the northern region and the Upper Peninsula show significant slopes in the landscape. Thus, Potential Erosion Problems could be a partial indicator for actual erosion problems, since the regions which would significantly contribute to erosion are in the Upper Peninsula, which shows few Potential Erosion Problems.

Additionally, the agricultural production pattern needs to be taken into consideration. Crop production is the primary commodity in the northeast quadrant counties, indicating cropping practices are correlated with high Potential Erosion Problems as would be expected. Once again, the conclusion is that a targeted green support program would not have a one-to-one relationship with 1991 CRP participants.[40]

[40] In fact, regressing CRP payments with the variables of Potential Soil Erosion Problems (Potential Wind Erosion, and Potential Soil Productivity Loss) indicates that the best regressed fit explains only 15 percent of the variation in counties receiving high CRP payments. The correlation coefficient for CRP and Wind Erosion is negligible (-0.03),

4.7 Location of Conservation Reserve Program and Manure Production

The following discussion is based on counties with CRP payment and with manure production (Map O.7, Appendix O), which is also summarized on Table 4.6. The table and the map show the combination of counties which match high CRP payments and high manure production.

High CRP Payments and High Manure Problems: The CRP payment distribution overlaid with animal manure production looked quite different from the map of CRP payments and all Agro-Environmental Problems in Michigan. Rank 4 with respect to CRP payments and rank 4 with respect to manure production (9.4 to 30 million pounds per county) (the northeast quadrant of Table 4.6), show that the counties are located in the central and south and Thumb region of the state.

Rank 3 with respect to CRP payments combined with a rank of 4 with respect to animal manure production (9 to 30 millions of pounds per county) are primarily located in the lower half of the lower peninsula. Specifically, the counties are Lapeer county in the Thumb region, counties in the western coast region, as well as counties in the south eastern part of Michigan. Rank 2 with respect to CRP payments and rank 4 with respect to animal manure production only corresponds to Ingham county. CRP payments with rank 1 and manure production of rank 4 do not exist. While rank 4 in CRP payments and rank 2 (1 to 3.5 million pounds per county) are only present in Arenac county in the Saginaw Bay area, rank 4 CRP payments are in no other counties present.

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while CRP and the Potential for Soil Productivity Loss has a correlation coefficient of a positive 0.08, which is equally negligible.

Table 4.6 CRP and Manure Production

Potential Environmental Problems (Manure)
(ranks 3 and 4)

4

Ogemaw

Ingham

Jackson
Kent
Lapeer
Ottawa
Washtenaw

Allegan, Barry
Calhoun, Branch
Cass, Clinton
Gratiot
Hillsdale
Huron, Ionia
Isabella, Lenawee
Montcalm
Sanilac

3

Alpena
Genessee
Menomenee
Missaukee
Muskegon
Oceana

Clare
Kalamazoo
Livingston
Newaygo
Osceola
Saginaw
Shiawassee
St. Clare
Van Buren

Jackson
Kent
Lapeer
Ottawa
Washtenaw

CRP Payments
(rank 1 and 2)

CRP Payments
(rank 3 and 4)

0 1 2 3 4

Chippewa
Oakland
Wayne

Delta
Cheboygan
Emmet
Gr. Traverse
Leelanau
Mackinac
Macomb
Mason
Monroe
Montmorency
Presque Isle

Alcona
Antrim
Gladwin
Iosco
Midland

Berrien
Eaton
Mecosta
St. Joseph
Tuscola

2

Alger
Baraga
Crawford
Luce
Marquette
Ontonagon
Roscommon
Schoolcraft

Benzie
Dickinson
Houghton
Lake
Manistee
Oscoda
Otsego
Wexford

Kalkaska

1

Potential Environmental Problems
(rank 1 and 2)

There are many counties with rank 3 with respect to CRP payments and rank 3 with respect to manure production (3.5 to 9.4 million pounds per county). Specifically, the counties can be found in the center of Michigan, the Saginaw Bay region, the Thumb area, the southeastern part of the state, and the southwestern region of Michigan.

High Manure Problems and Low CRP Payments: Rank 2 with respect to CRP payments and animal manure production with a rank of 3, the counties include counties along the western coastline, Genessee county, Missaukee county in the upper central area of Michigan, and Alpena on the north eastern coast of Lake Huron. The Upper Peninsula only has Menomenee county with these two ranks.[42] [43]

4.8 Location Of CRP Payments And Fruit And Vegetable Production and Potential Pesticide Problems

Fruit and vegetable production data in acres of production was collected. Map O.8, Appendix O, and Table 4.7 shows current CRP payments overlaid with fruit and vegetable production.[44] The reason fruit and vegetable production was overlaid with CRP payments was the assumption that farmers apply pesticides to vegetable fields and

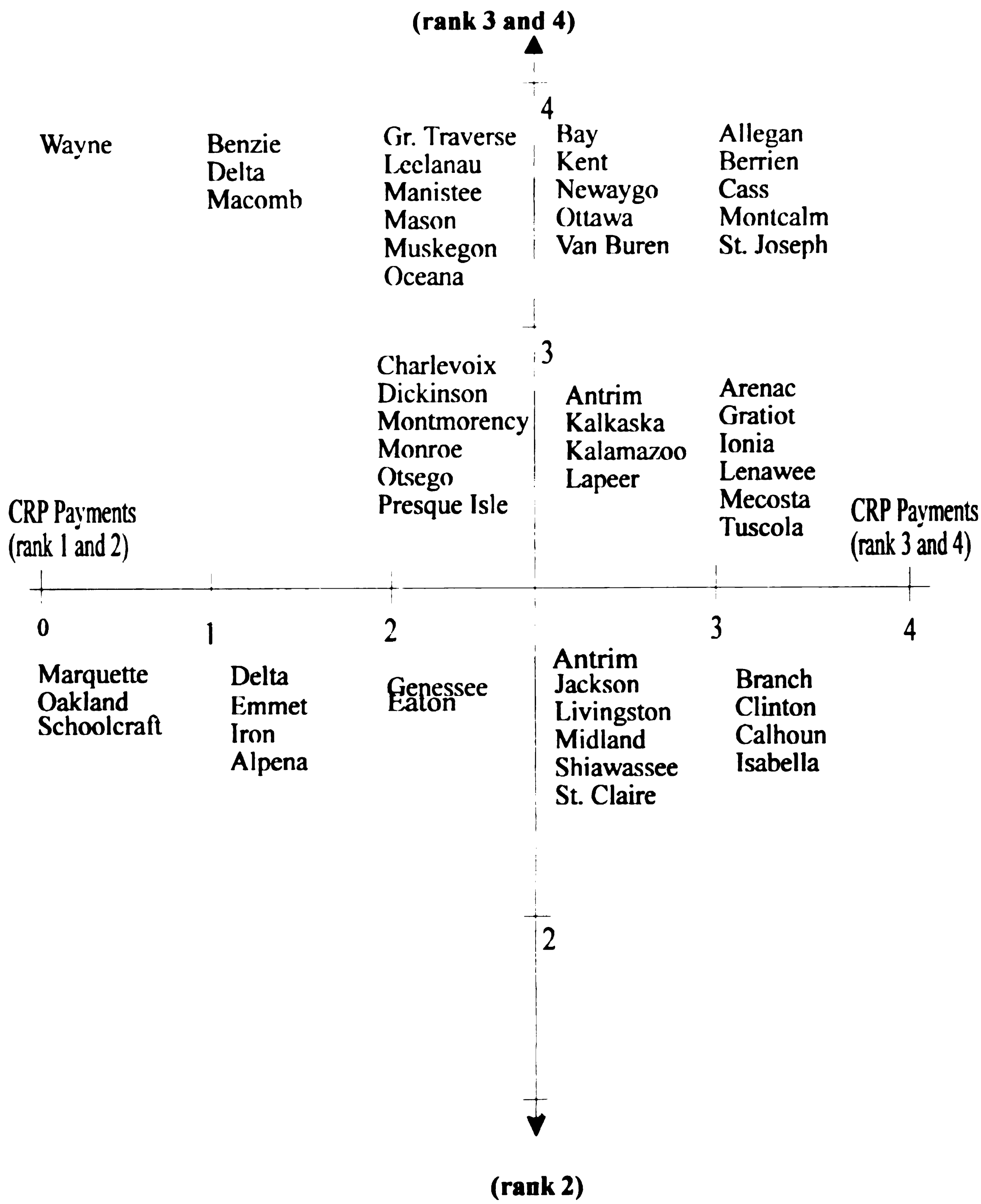
[42] Regressing CRP payments with the total manure production indicates that the best regressed fit explains 28 percent of the variation in counties receiving high CRP payments. The correlation coefficient between CRP and manure production is 0.52, indicating that there is a strong positive correlation between the counties with high CRP payments and the counties with high manure production.

[43] Additionally, after talking to county agents, it was relatively certain that almost no manure leaves the counties where livestock is produced. Most of the farmers spread the manure on their adjoining fields within the county of livestock operations. The exceptions are Midland, Claire, and Gratiot counties where small amounts of manure may cross county lines in cases where farmers have fields in the adjoining county and spread the manure of those fields.

[44] The remaining Michigan counties not in Table 9 do not produce fruits and vegetables.

Table 4.7 CRP Payments and Fruit and Vegetable Production

Potential Environment Problems (Fruit and Vegetable and Potential Pesticide Problems)



orchards. Unfortunately, there are no actual pesticide application data by county for Michigan. The only actual pesticide data were fruit application (total amounts and application rates). Although one can assume that considerable agro-environmental problem exists in the areas of fruit production, CRP payments and fruit and vegetable production is assumed to match poorly.

High CRP Payments and High Fruit and Vegetable Production: The map shows which counties have both high CRP payments and large amounts of fruits and vegetables (rank 3 and 4 with respect to CRP payments and fruit and vegetable production), i.e. the northeast quadrant of Table 4.7.

The only counties which shows both CRP payments and fruit and vegetable production as the highest rank are located in the south east. The same rank for both CRP payments and fruit and vegetable production are found in the counties of Arenac, Tuscola, Gratiot, Ionia, and Mecosta.

CRP payments with rank of 3 and fruit and vegetable production of rank 4 are located in the western region of the state and Bay county, while CRP payments of rank 3 and fruit and vegetable production of rank 3 are in the counties of Lapeer, Kalamazoo, Antrim, and Kalkaska. CRP payments with a rank of 2 and fruit and vegetable production with a rank of 4 is concentrated along the western coast of Lake Michigan.

High Fruit and Vegetable Production and Low CRP Payments: a CRP ranking of 2 compared with rank of 3 with respect to fruit and vegetable production can be found in the northern region, Dickinson in the Upper Peninsula, and Monroe in the south east. Few CRP payments (rank 1) are distributed in some counties experiencing rank 4 fruit and vegetable production, which are located in the counties of Macomb, Benzie, and Delta and Wayne.[45]

In all of the above regions, fruit and vegetable production is high and may pose considerable potential contamination to ground and surface water. Along the western shore, where all of the fruit and vegetable production occurs highly permeable soils exist (see map G.2, Appendix G). Some counties in the center of the state and parts of the Saginaw Bay region show moderately permeable soils, as do the western counties of the Thumb. In the Upper Peninsula, counties in question display highly permeable soils. The permeability of the soil is one of the most important factors in determining leaching capacity due to pesticide application on vegetable and fruit enterprises.

Additionally, the Potential Pesticide Leaching combined with fruit and vegetable production (map I.2, Appendix I) almost exactly fits the production pattern of fruits and vegetables. The entire western shoreline has a high potential for pesticide leaching, as well as some of the counties in the center of the state. Furthermore, pesticides subject to sorption, to clays and organic matter do not readily leach through the soil, but may be discharged into surface waters through runoff (National Research Council, 1993, p. 317). Furthermore, the topography of the counties is also an important consideration. As the map for Michigan's topography reveals (Eichenlaub, 1990), the counties with high fruit and vegetable production also have a high potential for runoff, because of sloped landscape.

[45] Regressing CRP payments and fruit and vegetable production indicates that the best fit explains 0.16 percent of the variation in counties receiving high CRP payments. The correlation coefficients between CRP and fruit and vegetable production are negigible (-0.06 and 0.07)

4.9 Location of CRP Payments and Endangered and Threatened Species in Michigan

As mentioned in chapter two, biologists and other scientists, physically collect the number of rare plant and animal species and a computer program ranks the data according to rarity (G1 through G5) for threatened and endangered species. The data was overlaid with CRP payments to determine the location of the counties matching high Threatened and Endangered Species and high CRP payments as shown on map O.6, Appendix O. This information is also displayed in Table 4.8.

High Threatened and Endangered Species and High CRP Payments: The only counties with both rank 4 with respect to CRP payments and rank 4 with respect to Threatened and Endangered Species (26 to 97 endangered and threatened species are found in those counties) which are located in the south western part of Michigan, with the exception of Lenawee which is located on the south eastern part of the state.

Rank 4 with respect to CRP payments and rank 3 with respect to species (14 to 26 rare species) are found in Hillsdale, Calhoun, and Barry counties. CRP payment rank of 3 coupled with Threatened and Endangered Species of rank 4 are only found in the southern counties of Michigan, while rank 3 with respect to Threatened and Endangered Species matched with the same rank 3 with respect to CRP payments are equally rare with county locations in the west and southeast of Michigan.

High Threatened and Endangered Species and High CRP Payments: Rank 2 with respect to CRP payments and rank 4 with respect to Threatened and Endangered Species are matched in the counties of Monroe and Emmet counties.

Table 4.8 CRP and Threatened and Endangered Plant and Animal Species

Threatened and Endangered Species

Threatened and Endangered Species rank	CRP Payments 0–1	CRP Payments 1–2	CRP Payments 2 (rank 1 and 2)	CRP Payments (rank 3 and 4)	CRP Payments 3–4
4 (rank 3 and 4)	Alger Chippewa Crawford Gogebic Keweenaw Luce Marquette Oakland Schoolcraft Wayne	Benzie Delta Houghton Mackinac	Monroe Emmet	Kalamazoo St. Claire Van Buren Washtenaw	Allegan Berrien Cass Lenawee St. Joseph
3 (rank 3 and 4)			Alpena Charlevoix Cheboygan Dickinson Leelanau Menomenee Muskegon Presque Isle	Jackson Kent Livingston Newaygo Ottawa	Barry Calhoun Hillsdale
(rank 1 and 2)	Baraga Ontonagon		Gr. Traverse Ingham Iron Macomb Manistee Montmorency Oceana Ogemaw	Alcona Bay Iosco Kalkaska	Branch Clinton Huron Mecosta Montcalm Tuscola
2 (rank 1 and 2)	Roscommon	Genessee Lake Mason Missaukee Oscoda Otsego Wexford		Antrim Clare Gladwin Lapeer Midland Osceola Saginaw Shiawassee	Arenac Eaton Gratiot Ionia Isabella Sanilac

CRP Payments axis: 0, 1, 2, 3, 4 — CRP Payments (rank 1 and 2) | CRP Payments (rank 3 and 4)

Threatened and Endangered Species axis: 4, 3, 2, 1 — (rank 3 and 4) | (rank 1 and 2)

The location of rank 2 with respect to CRP payments matched with rank 3 with respect to Threatened and Endangered Species are mostly found in counties scattered along the shores of Michigan. Starting in the Lower Peninsula on Lake Michigan these combination of ranks can be found in Muskegon and Leelanau counties, and on the shores of Lake Huron. In the Upper Peninsula, only Dickinson, and Menomenee counties are found with the above ranks.

Rank 1 with respect to CRP and Threatened and Endangered Species ranking 4 are in Houghton, Delta, Mackinac, and Benzie counties. Additionally, most of the counties which receive no CRP payments but have high Threatened and Endangered Species problems are located in the Upper Peninsula. In the Lower Peninsula, particularly, the counties of Benzie, Oakland, and Wayne counties receive no CRP payments but exhibit high Threatened and Endangered Species.

The counties in the northeast quadrant of the table are primarily engaged in livestock, some fruit and vegetable production as well as crop production, which may explain why those are the counties with the most Threatened and Endangered Species. County land in crop production combined with CRP payments suggests that at least some fields are idled, which may contribute to the loss of species if these fields are subject to emergency haying and weeding procedure. Additionally, in the counties which receive no or very little CRP payments, some crop production occurs. However, the primary products grown in those counties are vegetables, which may destroy habitat for some animal species. Similarly, erosion of pesticide contaminated soil may runoff directly into the surface water, having a negative effect on Threatened and Endangered Species.

The shifting of green payments away from CRP participants to targeting Threatened and Endangered Plant and Animal Species will be quite drastic. The only counties which would retain CRP payments or equivalent of green support payments would be in the southeastern corner of the state. These are the counties in the northeast quadrant of the table. These counties are heavily engaged in livestock and other agricultural production, which may lead to endangered plant and animal species.

Additionally, almost the entire Upper Peninsula has a high potential of losing endangered animal species. All of these counties would receive green support payments to avoid the possible extinction of species.[46] For a more complete analysis, it is necessary to compare the ERS data map for the Potential Improvement of Wildlife Habitat with the current CRP Payment distribution.

4.10 Location Of CRP payments And Wildlife Habitat Improvement

The map on Potential Wildlife Habitat Improvement and CRP payments was generated as Map O.7 (appendix O) and the counties can be viewed on Table 4.9. As map O.7, Appendix O reveals, the index numbers are quite high, indicating that Wildlife Habitat Potential is a real concern for Michigan and the nation in general.

High CRP Payments and High Potential Wildlife Habitat Improvement: Starting with rank 4 with respect to both CRP payments and habitat, the counties which match are primarily located in the upper Thumb region and some counties in the center and the

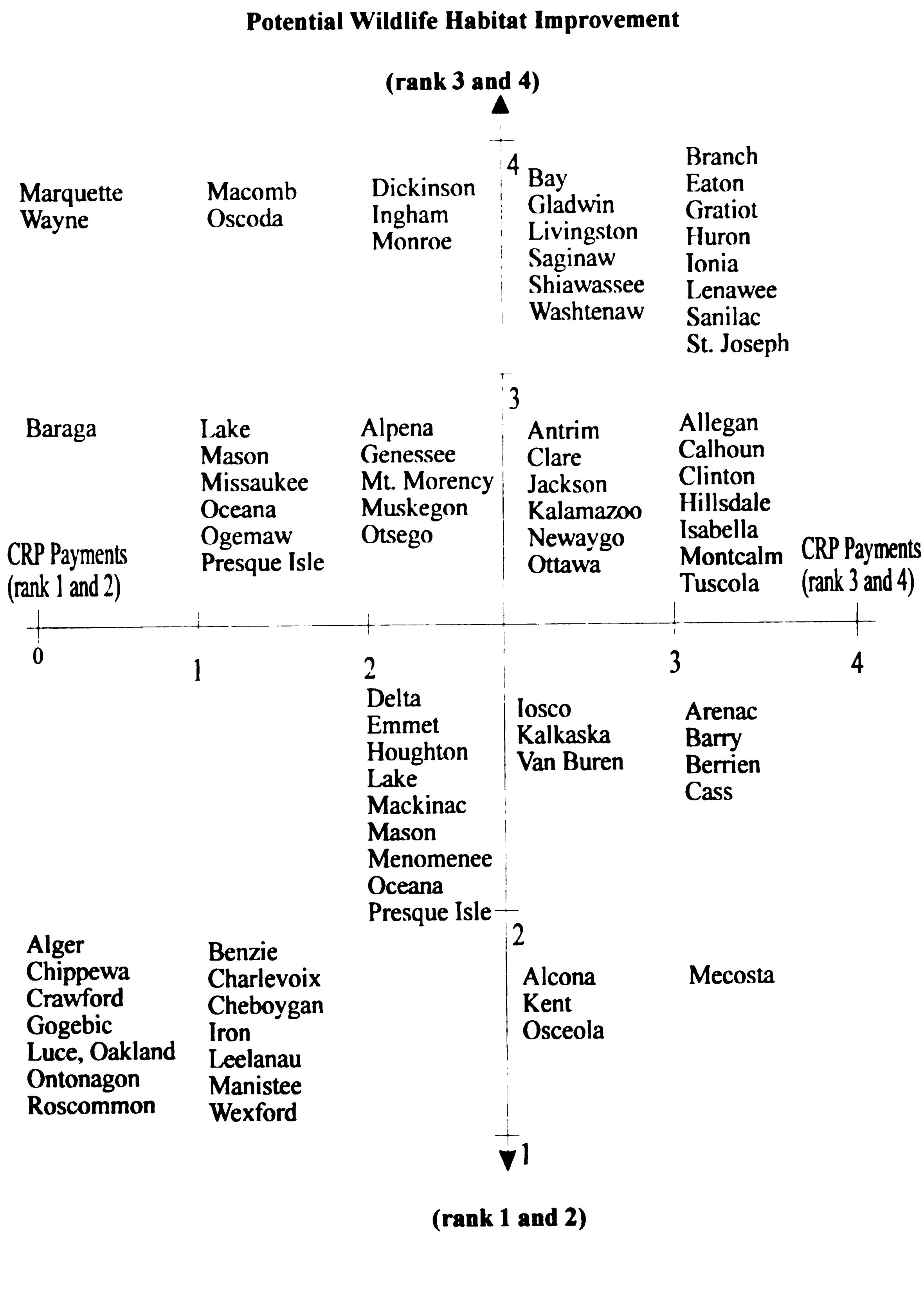
[46] Regressing CRP payments and Threatened and Endangered Species indicates that the best fit explains 0.1 percent of the variation in counties receiving high CRP payments. The correlation coefficient for CRP and Threatened and Endangered Species is negligible (-0.1).

southern border counties to Ohio. Continuing with rank 3 with respect to habitat, the counties receiving the maximum range of CRP payments are located in the vicinity of the counties with rank 4 with respect to both CRP payment and Potential Wildlife Habitat Improvement. Rank 3 in CRP payments and rank 4 in Potential Habitat Improvement shows that the counties are distributed from the south east to the Saginaw Bay and lower Thumb region. Rank 3 with respect to Potential Wildlife Habitat Improvement combined with rank 3 with respect to CRP payments are more spread out including the counties of Jackson, Kalamazoo, Newaygo, Ottawa, Claire, and Antrim in the north west.

High Potential Wildlife Habitat Improvement and Low CRP Payments: Counties with Rank 2 with respect to CRP payments matched with rank 4 with respect to Potential Wildlife Habitat Improvement are also few in numbers. Monroe in the south east corner, and Ingham county as well as Dickinson in the Upper Peninsula can be identified. Rank 3 exists for Potential Wildlife Habitat Improvement in Genessee county, Muskegon, and a few counties in the northern region of the state.

The remaining counties in the northwest quadrant of the table show rank 1 with respect to CRP payments. Rank 4 with respect to Potential Wildlife Habitat Improvement, the counties consist of Macomb, Wayne, Oscoda, and Marquette counties. Those with rank 3 with respect to Potential Wildlife Habitat Improvement which receives the smallest amount of CRP payments are located in the northern half of the Lower Peninsula and the Upper Peninsula.

Table 4.9 CRP and Potential Wildlife Habitat Improvement



Examining the map with Potential Wildlife Habitat improvement combined with CRP payments, one finds that many counties match in the northeast quadrant of the table. Most of the southern Lower Peninsula is engaged in crop production, some in vegetables and livestock, all of which are a potential threat to wildlife habitat.[48]

The entire Thumb, central, and south eastern portion of Michigan should receive payments targeted to Potential Wildlife Habitat Improvement. The retargeting to a green support program payment will occur in the counties in the upper left quadrant, namely the counties which receive no or little CRP payments but which exhibit high Potential Wildlife Habitat Improvement. The counties which already receive CRP payments but with high Potential Habitat Improvement are mainly those counties which are heavily engaged in crop, some vegetable, and livestock production.

After comparing the maps of Threatened and Endangered Plant and Animal Species from the Michigan Natural Features Inventory and ERS's Potential Wildlife Habitat Improvement, it becomes apparent that the distribution of green support payments are quite different from CRP payments.

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[48] Regressing CRP payments with Potential Wildlife Habitat Improvement indicates that the best fit explains 12 percent of the variation in counties receiving high CRP payments. The correlation coefficient between CRP and Potential Wildlife Habitat Improvement indicates that there is a weak positive correlation between the counties with high CRP payments and the counties with high Wildlife Habitat Improvement Potential.

4.11 Location Of Commodity Program Payments And Crop Production And Animal Units

Since the Federal Commodity Programs are designed to support the enterprises producing crops and, to a certain extent, livestock, the maps of commodity program payments and crop production as well as animal units are similar (Maps P.1 and P.2, Appendix P). Crops are produced in all counties of the southern half of the state as well as some counties in the upper half. Crop production is eligible for commodity program payments in most of the counties where crop production is most intense, i.e. the Thumb area, the center of the state, and the southern counties. In those areas, the acreage of crops produced ranges from 114,000 to 332,000, where the commodity program payments are also highest ranging from \$2.3 to \$6.7 million dollars per county. The remaining counties including western counties, eastern counties, and northern counties of the state correspond with the commodity program payment distribution with respect to production of commodity crops.

Approximately the same applies to animal units, however, there are discrepancies in the distribution of commodity program payments. Extensive livestock is produced in the center of the state and Thumb area (which matches the highest funds of payments distributed), but some western and south western counties receive disproportionate amounts of payments. The payments are not, however, for livestock per se, but for crops some of which may be destined as animal feed.

4.12 Federal Commodity Programs And The Effectiveness Of Achieving The Goals Of Agro-environmental Improvements

Three primary conservation policies were implemented in the 1985 Food Security Bill, including the Conservation Compliance Provision, Sodbuster, and Swampbuster. Conservation Compliance requires farmers to develop conservation plans for their farms as part of the eligibility requirements for commodity programs. Plans have to be made for implementation by the year 1995. Conservation compliance has faced general problems of implementation as well as problems of incentive for farmers. Higher market prices, and, therefore, lower deficiency payments, are a disincentive for conservation compliance due to the profits from farming every available acre. Additionally, when market prices are high, farmers are less concerned with financial penalties for non-compliance. Therefore, the effectiveness of conservation compliance depends upon the participation and implementation of farmers. Additionally, enforcement has been difficult because administration of penalties is in the hands of local governments. As Runge (1993) points out, only a relatively small number of penalties have actually been administered and many have been overturned on appeal especially in cases where the offending farmer is well-known (p. 16). Thus, even though the conservation compliance provision was designed to provide some conservation of natural resources, in many cases it has failed to do so.

Thus, it can be safely assumed that commodity program payments do not provide incentives to reduce agro-environmental problems. Additionally, it is clear that there is no match between agro-environmental problems and commodity programs since it cannot be distinguished between agro-environmental problems and commodity programs, since commodity program payments are distributed in most of the state.

4.14 Conclusion

Many counties with agro-environmental problems do not receive high CRP and commodity payments, even though the CRP was designed, after the 1990 Farm Bill, to include water quality issues as well as erosion concerns to achieve environmental quality. Some counties which receive little or no CRP or commodity program payments also have potential agro-environmental problems. Some counties would retain CRP like payments, however, others will be retargeted to take into account all agro-environmental problems.

Some land will need to remain idled and others may need to have various conservation practices such as filterstrips near water bodies applied. The next chapter will address the implementation issues of a green support program as well as alternative levels of implementation, the differences between whole farm systems versus site-specific solutions, and factors which influence farmer participation in a green support program. Lastly, it will address the consequences of targeted agro-environmental problems.

Chapter 5

Policy Implications

The concept of targeting seemed simple on the surface, however, it has been shown that a green support program is quite complex and involves choices which need to be carefully examined. First, this study was based on national data for potential agro-environmental problems (with Michigan data extracted); such data may not be enough on a state-wide level as to be sufficient for actual policy making. Improved data for a state-level analysis and policy setting is an important objective. Additionally, this study examined targeting to counties, which precludes the distributional effects for individual farm operations within counties as to their potential agro-environmental problems. It is important that actual data for site-specific for agro-environmental problems be included for more accurate targeting. That is, actual targeting would ideally need to identify priority areas such as watersheds and the priority farms within the priority regions. As this study demonstrated, this identification is a difficult task. This thesis has shown that there are many policy questions and research issues which have to be resolved.

The goal of a green support program is the reduction of agro-environmental problems. There are many issues, which will be addressed in the following sections. Two important issues are a.) the implementation of the alternative targeting green support programs, i.e. will they be voluntary or mandatory, b.) who will be in charge of the policy (local versus state versus federal).

Additionally, the issue of whether the program should involve whole farm systems or site specific solutions, i.e. Best Management Practices, will be addressed as well as some of the factors influencing producer participation. Furthermore, the consequences of targeted agro-environmental problems will be examined and needed further research will be identified.

Priority areas can be defined as separate agro-environmental problems such as the problems discussed in this study (potential erosion, surface and groundwater, and wildlife problems). If the priority areas were to be defined in such a way, the erosion priority areas would incorporate the southern counties of Michigan, as well as the western lake shore counties and the central counties of Michigan. Surface Water priority targeting would fall in the Thumb area, in the western lake shore counties, in the central Lower Peninsula, and in the central Upper Peninsula. Groundwater priority areas would be the western lake shore counties from Leelanau county in the north to Berrien county in the south, including the south western counties from Hillsdale to Barry counties. Wildlife problems occur primarily in the Thumb area, possibly due to extensive livestock and crop production, in the Saginaw Bay area, in the western, central and southwestern counties of Michigan, as well as in some counties in the north of the Lower Peninsula. If all individual priority areas are overlaid, the priority areas would include the western lake shore counties, the Thumb area, as well as the central counties of Michigan.

A county example is Barry county in the south central region of Michigan. It receives more than $807,000 in CRP payments, and it lies within a priority area of potential surface- and groundwater contamination, as well as potential erosion problems

(Maps N.2 to N.4) since most variables in Barry county fall within the fourth quantile of ranges. Specifically, Potential Sediment Delivery has an index of 1.5 from a high of 1.5 (Map K.1) in Barry county, the Potential for Filterstrips has an index of 5.1 from a high of 12 (Map K.3) and the Potential for Nitrogen Runoff has an index of 76.8 from a high of 84 (Map K.2). As for the potential groundwater problems, Barry county Potential Nitrate Leaching has an index of 4.03 from a high of 5.1 (Map L.1), and Potential Pesticide leaching is equally high with an index of 2.7 from a high of 8.6, (Map L.2). Erosion problems are not as severe, with the Potential for Soil Productivity Loss (Map J.1) having an index of 1.0 from a high of 1.6 (fourth quantile), and Potential Windblown Dust having an index of only 0.5 from a high of 2.8, which lies in the second quantile (Map J.3). Potential Wildlife Improvement does not seem to be a concern in Barry county, with an index of 46 from a high of 79 (Map M.1).

Agricultural production consists primarily of livestock production with animal units of 16,000 to 44,000 units (third quantile), which includes mainly cattle and turkeys (Map F.4). Barry county receives $1,885,150 in commodity program payments, although no reported fruit or vegetable production occurs in Barry county, crop production is relatively high with 70,650 acres (19.8 percent of the county's total acres) (Maps F.1 to F.3)

Some factors contributing to the high potential of agro-environmental problems in Barry county may be the topography of the county. Barry county produces crops on 634 acres with a slope of 0 to 2 percent which has streams present and 98 acres with slopes of 2 to 4 percent, possibly contributing significantly to agro-chemical runoff and erosion

(Map G.5.1 and G.5.2). In general, the county lies within relatively high sloped lands (Map G.1). Additionally, the county has high to moderately permeable soils, which contributes to chemical leaching (Map G.2). Furthermore, 1.4 to 2.8 percent of the county consists of inland lakes, which is equivalent to 1,000 to 1,400 lakes in Barry county (Map G.3). The miles of rivers in the county lies in the range of 350 to 700 (Map G.4). Considering the general characteristics of the land in Barry county, with miles of river, and number of lakes, it is possible that these characteristics contribute to surface water pollution potential. Thus, targeting Barry county would make sense from a county level perspective.

5.1 Implementation Considerations

A cost effective green support program will invariably involve targeting. There are more issues to be resolved in the design of such a targeted program. Targeting has to be politically and economically feasible, as well as environmentally beneficial. In general, a green support program would be more politically feasible if it were on a voluntary basis, since policy makers as well as the agricultural community favors voluntary programs over regulatory programs (Office of Technology Assessment, 1990, p. 279). A green support program must also be economically feasible such that there is minimal private costs (taxes or increased prices for the general public). Targeting of green payments to agro-environmentally vulnerable farms may involve adjustments on the farms which would no longer receive CRP payments or green support payments.

These farms will have to go through an adjustment period which may, in some cases, raise costs for the farmer.

A targeted green support program would require accurate information. The data collection for the agro-environmental problems in this study were based mostly on potential environmental problems. A green support program ideally would be designed around accurate data on agro-environmental problems, their location, nature and magnitude. The scale at which the data is collected is also an issue.

The Economic Research Service's environmental data is on a national scale, and different regions have different agro-environmental problems. For example, wind erosion is a real concern for the desert regions of the west, but may not be as large a problems in other regions of the nation. Pesticides and nitrogen leaching may be a potential problem in certain regions where there are high leaching potentially due to the topography and soil characteristics. National data tends to obscure state-level specific data of importance. For example, potential nitrate runoff could not be explained only from the Economic Research Service's data set; explanation required the examination of the topography and soil characteristics of the state.

There are tradeoffs associated with the use of potential versus actual agro-environmental data. It would be ideal to design a program with performance standards, but performance standards require actual data to be available on the agro-environmental off-site problems regarding surface and groundwater problems, erosion problems, the manure production and farm management practices, and wildlife habitat quality. To date, such data is unavailable and, therefore, pollution prevention design standards aimed at potential agro-environmental problems would most likely be used in an initial program.

Because of the difficulty of precise identification of problems and the probable use of program design standards, voluntary programs might be the most feasible approach. But if farmers are voluntarily implement design standards, they need to be aware of the relationships between their agricultural production and resulting environmental damages. Education as to pollution prevention, the technologies and practices would need to be included in the design of programs. The program could also be evolutionary. If the green support programs fail to continue to protect the environment, the program needs to be reevaluated and changed, if needed.

5.1.1 Voluntary Approaches

Voluntary approaches involve agro-environmental pollution control implemented by farmers without external constraints. A voluntary green support program would primarily rely on research and development of environmentally protecting practices, farmer education to increase the awareness and knowledge of the agro-environmental problems and the solutions to reduce them, technical assistance to assist farmers to implement new practices. Farmer participation tends to increase when they are aware of their contributions to agro-environmental protection which they believe are important, when the costs are within reason, and when the producers are involved in the design, implementation, and enforcement of the green support program (Batie, 1995, p. 90). Additionally, the participation rates increase when education programs are targeted towards the producer needs (National Research Council, 1990, p. 189-191). Thus, a primary advantage is the flexibility and individual freedom a voluntary green support program would allow the farmer.

A voluntary green support program also has disadvantages. One of the most important concern are the participation rates, since many producers may not be willing to participate or may not know that their operations have any agro-environmental problems. However, as Batie (1994, p. 90) concludes, a "voluntary GSP [Green Support Program] is most likely to be successful if it targets priority areas and priority farms within these areas, and if it emphasizes tailored site-specific planning processes with meaningful producer involvement." Regardless, nonparticipation may still be a problem if participating producers reduce agro-environmental pollution on their own land, but nonparticipants continue to pollute.

The cost of a voluntary green support program could be high. If potential agro-environmental problems exist in a majority of the counties, those counties which already receive CRP payments could keep the funds combined with land idling and/or conservation practices. Additionally, the counties with high potential environmental problems which receive no or little current CRP payments would also receive green support payments. The CRP budget may not be sufficient to distribute both current CRP payments and payments for the counties receiving no payments. A possible solution to reduce the budget problems may be to only target individual farms within targeted priority areas.

In addition, there are program implementation costs. State and/or federal and local agencies must be properly trained to assist and to work with producers as to all aspects of the agro-environmental problems and the green support program. Analyses of the soil characteristics, input use, profits, and environmental quality must be done by competent agency, University, or consultant scientists.

5.1.2 The Mandatory Approach

A mandatory approach to a green support program involves agro-environmental pollution control which are implemented by producers in response to laws and regulations which are subject to penalties for noncompliance. A mandatory approach requires (1) a precise specification of the goals and how to achieve them, (2) clearly defined penalties, and (3) a verification and enforcement mechanism (Office of Technology 1990, p 280). Examples include partial pesticide bans and prohibition of pesticide application at specific times.

The primary advantage of a regulatory approach over a “green” payment program is that the most vulnerable areas could be targeted if there were sufficient knowledge of the agro-environmental problems within a region. However, the targeting approach to the most vulnerable farms or fields within a priority region, such as a watershed, may place the producers in a distinct financial disadvantage because of increased crop production costs (unless compensated). Enterprises which may not be in the financial position to absorb the increased cost may have to close their businesses as a result. While economic theory suggests that internalizing the externalities of non-point source pollution so that they enter the farmers decisions, policy makers may not wish to disadvantage some producers. Thus, the challenge to a mandatory green support program may be to develop regulations which are strict enough to achieve environmental goals, but which do not threaten the financial viability of enterprises.

However, technologies available for the implementation of conservation practices, such as Best Management Practices, or Integrated Pest Management may not impair the costs for the farmer; it may even improve profits. Reducing inputs such as fertilizers and pesticides to only the amounts needed by the plants may be a way to reduce costs for farmers and improve profits. More environmentally protecting technologies for farmers should be available in the future because, regardless of whether the green support program is regulatory or voluntary, the program should "induce" researchers to develop new technologies.

In addition to the loss of personal freedom, a primary disadvantage to a mandatory green support program are the costs of regulating and enforcing the program. If regulations are not properly designed or if data is not available, enforcement and monitoring is unlikely, and if penalties are too small and are not enforced, producers may simply disobey the laws.

Additionally, since regulations are popular with neither the agricultural community nor the state and local agencies, a mandatory program may fail. Furthermore, since agro-environmental are site specific and involve multiple resources, a mandatory approach that is flexible enough to be site-specific may be too difficult to design unless data is available to require compliance with performance standards.

5.1.3 Cross Compliance

Cross-compliance approaches involve requiring implementation of environmentally protecting practices or systems to control agro-environmental problems in order to qualify for commodity program payments. A cross-compliance approach incorporates the specification of the pollution-reducing management practices, a government based program which provides the commodity benefits only to those producers who implement and maintain these practices, and a verification and enforcement mechanism to ensure that producers are complying with the management program. Cross-compliance emphasizes a quasi-voluntary approach in the sense that producers voluntarily implement pollution control practices in order to be eligible for commodity payments.

Cross-compliance approaches tend to be politically more acceptable than mandatory approaches (Office of Technology Assessment, 1990, p. 279). However, the primary disadvantage, as discussed before, is that not all producers with agro-environmental problems on their land will participate and some regions with potentially severe pollution problems will be missed.

Cross-compliance incentives depend essentially on the base-program incentive, which, in the current form, may not be enough to induce participation or reduce agro-environmental problems. If federal program payments were reduced to decrease program costs, the penalty for non-compliance with conservation provisions also would be reduced (Office of Technology Assessment, 1990, p. 279). Additionally, were the commodity programs eliminated altogether, cross-compliance incentives would also disappear.

5.2 Alternative Levels of Implementation

Most farm programs are administered by the federal government while environmental policies are largely legislated by state and local governments. Additionally, the environmental community and the agricultural community typically have different conceptions as to the role of the federal government regarding issues within their domain. However, for a green support program, all levels of government will likely be involved in some sort in the implementation and administration of a green support program. This question of the appropriate level of design and implementation of green payment programs is an important future research area, with many complexities to consider.

5.2.1 Federal Government

Issues such as uniformity, consistency of standards, and equal treatment of producers among different regions are a rational for the involvement of the federal government in a green support program. Additionally, there is a need for accurate and detailed scientific information. State and local governments may not have the personnel capable to provide data on agro-environmental problems or the financial resources to carry out the necessary tasks of data collection and analysis. The dissemination of data by the federal government could reduce the cost and duplication of these tasks.

Furthermore, while agro-environmental problems begin locally and are, for some problems site-specific, affecting the surrounding environment (off-farm impacts) such as water, soil, and wildlife, many such problems cross state and national boundaries. These transboundary agro-environmental problems may be impossible or too expensive for state and local governments to manage. The most obvious agro-environmental problem which may have transboundary effects is runoff into rivers and streams. Thus, the agro-environmental problems are not constrained by political boundaries or private property lines. Here, a role for the federal government is most obvious.

The federal government may be in a position to assist states and localities in the review of climatic and geologic conditions which influence agro-environmental problems. The extent of erosion as well as nitrogen and pesticide leaching and runoff is dependent, in part, on the geology and climate of the regions. Furthermore, the development of an adequate mechanism for states to translate research results, provide calculations on risk assessments, and standardized guidelines could be a responsibility for federal agencies. Financial support and technical assistance for the implementation of a green support program may be another role for the federal government.

Even if the federal government provides the lead for green support programs, there remains the question of which federal agencies will be responsible for the different issues in the implementation of a green support program. The two federal agencies with the authority to control agricultural nonpoint pollution are the USDA and the Environmental Protection Agency (EPA). Both agencies have different approaches to accomplish the goals of environmental protection. The USDA focuses on agricultural production and emphasizes voluntary bottom-up approaches, while the EPA is involved in pollution abatement, with a regulatory, top-down approach (US Congress, Office of Technology Assessment, 1990, p. 278). A coordinated approach could be implemented by which each agency has certain responsibilities. Such an approach is similar to many ongoing programs with respect to environmental quality programs. Thus, the USDA might be in charge of crop and farm management issues as well as education, technical assistance in the implementation of the management practices with respect to agro-environmental problems, while the EPA could have the responsibility of performance standard setting or the regulatory structure of any green support program. EPA has better access to information as to health and ecological impacts of nonpoint source pollution and thus could assist in priority setting. The United States Geological Service (USGS) could then take on the responsibility of data collection, interpretation and coordination. Coordination mechanisms can span from inter-agency agreements to actual consolidation of efforts. For example, joint agency coordination of these agencies into a single entity such as a "subagency," like a Department of Natural Resources, whose main responsibility is agro-environmental problems, might allow for clear identification and accountability of each agency. Obviously, such an approach is expensive and would only be feasible where adequate personnel and financial resources are available.

5.2.2 State Government

The primary justification for state government involvement is that most agro-environmental problems are site-specific or regional, not national. As was established in previous chapters, the data set used for this study was on a national level from which was extracted the data for Michigan. It was also established that some variables were skewed and the may not have been completely accurate with respect to Michigan's agro-environmental problems. The states may have a better understanding of the agricultural production patterns as well as the agricultural production practices in their states and could be in a position to intensively study the agro-environmental problems and, in some cases, collect the data. For example, Wisconsin has developed a comprehensive program to address and solve water quality problems within the state.

Although not labeled a green support program, the "Wisconsin Nonpoint Source Water Abatement Program" is a comprehensive program which emphasizes nonpoint source pollution. The difference between a green support program and the Wisconsin Program is that contracts need to be signed by land owners whose land falls within the priority environmental pollution areas, regardless of whether the areas are in rural agricultural regions or urban areas. Additionally, breach of contract can result in the repayment of cost-share funds distributed to those enterprises. Additionally it focuses on water quality only while the green support program proposed focuses on all agro-environmental problems in the state of Michigan.

Officials in Wisconsin have recognized that surface - and groundwater quality would not be obtained without an aggressive program for the control of nonpoint source pollution. The result of this recognition was the Wisconsin Nonpoint Source Water Pollution Abatement Program. The program is underlain by three premises: (1.) because pollutants can originate from many different nonpoint sources, effective control of the sources must be comprehensive; (2.) because of the comprehensiveness of the program, the goals for the state's water quality are not the same as other conservation programs, such as erosion programs; and (3.) the program requires strong technical assistance and leadership by the state's water quality agency, essentially for the purpose of identifying where the surface water problems are located.

The difference between the Wisconsin program and other states' programs is that it (1.) focuses on hydrological units, rather than political boundaries, (2.) deals with urban as well as rural areas, which may have water pollution problems, and (3.) "relies on systematic processes to identify, rank, and select critical watersheds and portions of watersheds to receive comprehensive attention." The Wisconsin program, therefore, focuses available funds for technical assistance and educational support where the maximum reduction in water pollution can be achieved. The hydrological unit approach ("priority watershed approach") permits all categories of urban and rural nonpoint source water pollution within a watershed to be identified and controlled through the implementation of management practices. There are six criteria for project selection:

1.) the severity of water quality problems
2.) the magnitude of the pollutant load into the lakes and streams that is likely to cause pollution and the potential to decrease the load
3.) landowners' willingness to participate
4.) the willingness and capabilities of local agencies to carry out the projects
5.) the willingness and capabilities of local agencies and other units of government to control other sources of pollution (e.g. establish erosion control ordinances for construction sites
6.) the potential public use and benefits that will result from the program

Furthermore, the priority watershed program consists of two parts. Part one is the technical assessment which sets the watershed goals by (1.) evaluating the water quality problems and identifying the water quality objectives, (2.) identifying the primary nonpoint sources as well as other pollutants such as point sources and septic systems, (3.) determining the improvements that can be obtained through nonpoint source control measures, and (4.) identifying management needs by determining the priority areas as well as the management practices, i.e. BMP's, which will effectively achieve the water quality goals.

Part two consists of the implementation strategy which outlines the procedures by which to achieve the goals. It analyzes (1.) the responsibilities necessary to accomplish the technical assistance, (2.) the agencies responsible to carry out these responsibilities, (3.) the time frame for the projects, (4.) the staff time needed for the project, and (5.) the calculated cost-share money for the implementation of the management practices.

After the approval of a priority watershed with a significant environmental problem, a three year time frame is allowed during which landowners as well as agencies can sign the cost-share agreements for the design and implementation of the BMP's. Five years are allowed to install the BMP's from the time the cost-sharing agreement is signed. The cost-share recipient must operate and maintain the BMP's for, generally, 10 to 20 years. Breach of the cost-share contract can result in the repayment of all cost-share funds received with interest added.

Thus, it is possible to coordinate, design, and implement a state-level green support program. Although the agricultural production in Wisconsin is likely to be different from Michigan's, it is apparent that the state of Wisconsin experiences the same environmental problems stemming from agriculture as Michigan. Thus, a similar comprehensive program to that of Wisconsin would be effective in Michigan. Michigan has well defined watersheds which can be targeted and which experience agro-environmental problems, particularly from nutrient runoff.

There is also more flexibility if the states have the responsibility of designing and implementing a green support program. The flexibility provides the ability to set specific goals and to design more innovative solutions which target the individual problems of the state. The state government knows their own agricultural community's characteristics as well as the preferences of the general population regarding environmental quality. States have their own unique history and culture that can influence the design and implementation of successful green support programs. Additionally, the state government may be in a better position to convey the information to the agricultural community than would a federal government agency.

Despite the advantages of state authority over a green support program, there remains the possibility that without a federal presence, states may refuse to act. State agencies may not be able to resist the pressures of lowering environmental standards, or lengthening the implementation schedules and the like. Additionally, duplication of data collection, information gathering, and non-uniform standards in the data could result if states independently take the responsibility of implementing a green support program. State government may also not have the resources for policy design, implementation, and enforcement.

5.2.3 Local Government

Agro-environmental problems start locally. Local governments could share the responsibility to identify the agro-environmental problems within their boundaries. It is possible to use an expert panel for each local government to identify agro-environmental priority areas, and draft possible solutions for each of the problems. County extension agencies would be a part of the process, whose agents could form the panel to share information on agro-environmental problems in their counties. Local governments could also take the responsibility to communicate with the agricultural community and provide educational material regarding conservation practices, agro-environmental problems, and the benefits to agricultural areas. This approach is used in Wisconsin as part of their state-based nonpoint pollution program.

5.2.4 Interaction Between All Levels Of Government

For the design and implementation of a green support program, it may be desirable, to involve all levels of government. There are many alternatives for such inter-governmental interaction. For example, the federal government may take the responsibility for broad program guidelines or for the funds to states or localities. Additionally, technical assistance to the states may be a task most appropriate for the federal government as well as providing general guidelines for environmental quality. The federal government may be in charge of identifying the transboundary agro-environmental problems and provide assistance to states as to possible solutions. States, with the assistance of local governments, would then identify the state-specific agro-environmental problems. The design, management, and maintenance of the green support program might be the primary responsibility of the states. Local governments' responsibility might play pivotal roles in actual implementation of programs. Particularly important for increasing voluntary participation in the program might be local government partnerships with producers in the design and implementation of a green support program. Additionally, a public/private partnership may be another possibility, where the private sector (suppliers of chemicals, etc.) provides research on specific conservation practices, such as information on pesticides and fertilizers, while the public sector provides funds for research. Additionally, a public/private partnership could involve cooperation in the design and implementation of a green support program such that agricultural production may become more efficient and cost effective.

An additional complexity in need of more research in the design of a green support program is to examine whether the green support program will involve site-specific solutions or whole farm systems to reduce agro-environmental pollution problems.

5.3 Site Specific Solutions versus Whole Farm Systems

Site-specific farming refers to a set of technologies which are designed to enable the producer to adjust his/her farming practices from point to point across an individual field. Site-specific solutions may be best if different parts of a single field contain different levels of nutrient and pest problems, and site-specific technologies allow producers to determine the differences (Office of Technology Assessment, 1995, p. 37).

A site-specific approach is most appropriate for input management such as pesticide and fertilizer application for individual fields which are known to have soils which are susceptible to erosion, runoff, and leaching. Site specific approaches may be most advantageous for farmers who produce crops which require a large amount of fertilizers and pesticides, here nutrient management might allow producers to decrease inputs or to substitute more suitable ones. Reduced input use results in cost savings for producers, however, it could decrease yields and may require other investments which may reduce profits.

Increased input efficiency could reduce the total amount of nutrients applied to a field, which could result in the reduction of total pollutants available for contaminating soil, runoff into streams, and leaching into groundwater. However, improved input efficiency may also depend on the timing of application, the characteristics of the chemicals, the application methods, and the application location on the field. Thus, even if inputs are reduced, if application of pesticides and fertilizers are spread on fields near water banks or on porous soils (which may accelerate the leaching of the chemicals), the environmental effects may not be adequate to improve environmental quality. Nevertheless, site-specific solutions may be more cost effective, since only certain fields are targeted, rather than the entire farm. This approach may also be easier for producers to implement because the complexity of this approach is relatively low. Record keeping on the part of the producer may be necessary.

Although it is tempting to design green support programs focused on the adoption of specific management practices (BMP's) to reduce agro-environmental problems, this approach may not be appropriate in all cases. Producers, farms, practices, and regions may be too diverse to successfully adopt individual practices and may not be suitable for every situation, and there are many unknown linkages between environmental quality, the use of inputs and profits for producers. The diversity of individual farming practices increases program complexity and implementation costs (Batie, 1995, p. 76).

Thus, one approach may be a green support program based on a whole farm plan with integrated, multidimensional changes in farming systems to meet environmental goals. The objective of a whole farm system is to achieve both economic effectiveness and environmental quality. A whole farm system involves examining the entire farm as a system and changing the way the producer collects information and makes decisions. "Plans, thus are information-gathering, recommendation-building exercises rather than a selection of management practices from a list of approved BMPs" (Batie, 1994, p. 91). Although a green support program relies on whole farm system planning, not every farm can be involved in the program since there are not enough resources to be distributed to all farms. The important issue in whole farm planning with respect to a green support program is to target the priority areas, i.e. the areas with the most agro-environmental problems such as a watershed and the farms within these priority areas.

Thus, it is also important to maintain agricultural production in the long term. Simply taking away payments for commodity programs and CRP Payments without compensation, be it in the form of technical assistance to improve output, or cost-sharing to assist farmers to adjust and to prevent those areas which currently do not exhibit extreme environmental problems from becoming agro-environmental problem areas.

Perhaps frequent studies need to be conducted to determine the status of the production pattern, output, and farm income.

In addition to addressing agro-environmental problems, the whole farm planning program could consider the effects of input management changes and other conservation practices on producers' profits. The changes likely to affect profitability would be adjustments to agricultural practices and the additional necessary labor and time requirements for the producer to implement, manage, and maintain the conservation practices (Heimlich 1995, p. 23).

Another complexity with the design and implementation of a green support program that requires more research are the factors which influence farmer decision making. The subsequent factors influencing participation in a green support program are an important consideration for policy decision makers.

5.4 Factors Influencing Farmer Participation

Perception and profitability of the green support program practices for the affected producers are certainly primary factors influencing producer participation. If the technology required for implementation is perceived to be profitable and beneficial for the producer, he/she is more likely to voluntarily participate in a green support program. "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") (Batie, 1995, p. 81). Additionally, as Batie (1995) asserts, producer perception will be weighted by the uncertainty level of the outcome of the new farming system, i.e. "the more uncertain producer perceives the outcome, the more likely will be the presumption that it will be negative" (1995, p. 81).

To achieve the goal of high voluntary producer participation, education programs must be available to demonstrate the financial and environmental benefits. As a case study to improve nutrient management in Iowa reveals, that state level programs including education, technical and financial assistance resulted in 52 percent of producers reducing the application of chemical inputs compared to a decade earlier (National Research Council, 1993 in Batie, 1995, p. 82). Thus, state-wide involvement in demonstration projects could be an essential component of a green support program.

Another factor influencing the participation is the heterogeneousness of the agricultural community. Some producers have more access to information and, therefore, are more able to make informed decisions regarding the production practices, their objectives, and the willingness to take risk. To overcome the lack of information, the states and counties could provide better access of information through demonstration projects. Additionally, the Office of Technology Assessment (1990 in Batie, 1995, p. 85-86) suggests that producers make production decisions within short year-to-year time frames, which may discourage financial and time investments to address agro-environmental conservation practices. This short term planning may discourage producers from taking the risks of participating in the green support program for the long term. Thus, the green support program may need to be flexible enough in some cases to take into account possible year-to-year changes in agricultural production and profits. Such flexibility may influence long-term technical assistance, financial support for changing conservation practices when needed, and educational programs as to the available conservation technologies for different production patterns and circumstances.

Some targeted producers may simply be unwilling to participate in a green support program because of perceptions that their farms have no agro-environmental problems, even though it lies within a priority area. Thus, lack of knowledge about the conditions on producers' land must be overcome by targeted and farmer-specific information demonstrating to producers that there are potential agro-environmental problems on their lands and of any benefits to them of a green support program. This education may involve knowledgeable county agents to personally meet with the individual producers and demonstrate the agro-environmental problems as well as the solutions to reduce these problems. The decision making processes and the subsequent participation in a green support program as well as the linkages to local agency involvement regarding education and dissemination of knowledge is an important research issue.

5.5 Data Limitations

Regardless of which government will design, implement, and maintain the green support program, or whether the responsibility will be as a combination of federal, state, and local government, the data collection is of primary importance. For this study, data on agricultural production and manure output for the state of Michigan was readily available through state and federal publications. Data on agro-environmental problems were provided on a national basis by the Economic Research Service and extracted for the state of Michigan. However, the national Economic Research Service data is too aggregated to identify precise problem areas for local planning purposes. Additionally, the data were on a potential, not actual, basis.[49] Additionally, actual data used for threatened and endangered species provided by the Michigan Department of Natural Resources came in a format which demanded time to reformat to be useful. Furthermore, it was based on sightings of threatened and endangered plants and animals. The data was not on a county basis but on a species basis and had to be converted to a county level to be mapped using Atlas GIS. Additionally, the data were neither tab nor space delimited, rather, the data was character delimited which no database was able to read.

Therefore, a standardized database is needed in order to use agro-environmental data in a meaningful fashion for policy making. Additionally, data has to be collected regarding actual agro-environmental problems to improve targeting and to monitor and evaluate agricultural performance over time. Additionally, data gaps need to be identified to improve agricultural policy making.

5.6 The Dynamics Of Agriculture And Agro-Environmental Problems

This study was essentially a "snapshot" in time regarding agricultural production and agro-environmental problems in Michigan. However, agricultural production patterns and the resulting environmental problems stemming from agriculture change over time. If current trends continue, for example livestock production could increase over the next few years, agricultural policy makers could change federal farm policy such

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[49] Although the data for Michigan were extracted, it had to be manipulated to be useful for analysis.

that producers may grow whatever commodities they chose and could return to crop production.

In order to improve agricultural policy making in the long run, this study would need to be expanded into a dynamic analysis. This analysis would need to take into account past agricultural production, perhaps collecting data for agricultural production over the decades and, based on the past and foreseeable future production.

5.7 Recommendation For Further Data Collection and Research

This study was designed to provide a preliminary analysis of the agro-environmental problems in Michigan, using data based on potential problems. There are obvious problems in identifying the farm-specific problems, the management practices, the implementation of a green support program, and the dynamics of agriculture in Michigan. Following is a list of recommendations for further data collection and research, which would improve the analysis of the design of green support programs.

- collection of actual data for agro-environmental problems in a priority areas.
- collection of actual data for agro-environmental problems on priority farms within the priority areas.
- collection of data on current farm practices
- collection of data for agricultural production trends and changing agro-environmental problems over time for a dynamic analysis.
- collection of data on farmer behavior for possible educational projects as to the agro-environmental problems on their farms.
- research on GIS and its potential for more accurate mapping
- analysis of public and private support levels for a green support program.
- analysis of design-, implementation-, and maintenance costs for a green support program.
- analysis of public sector involvement, i.e. which agencies will be involved and what responsibilities will they have.
- analysis of competitiveness of the agricultural sector if green support programs are implemented.

- analysis of the possibility of eliminating all federal commodity programs for a green support payment.

5.6 Conclusion

It was demonstrated throughout this study that green support programs have merit in the sense that they potentially reduce agro-environmental problems and could be designed to be cost-effective and politically feasible. Additionally, green support programs divert from conflicting agricultural programs which emphasize environmental quality concerns. For example, the current CRP focuses primarily on highly erodible lands with some water quality concerns included. Commodity programs focus on supply control and income assurance, with cross-compliance as a requirement. With a green support program, these conflicting goals of each program would be diminished since the program would focus only on agro-environmental problems and the identification of priority areas and priority farms within these areas. Income assurance would still be in place through the green payments while, at the same time, reducing agro-environmental problems. However, there are many complexities which need to be resolved before the design and implementation process can begin.

This research proposed to analyze the distributional effects of a change in policy, so as to possibly reduce agro-environmental problems. Through this study, state policy-makers will have more flexibility in nonpoint-source pollution prevention program. With accurate data and subsequent analyses, it would be possible for states to identify the relationship between agricultural production and agro-environmental problems areas.

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Appendices

Appendix A

Michigan's Pesticide Use and ERS's Pesticide Exposure Variable

Appendix A

A.1 Michigan's Pesticide Use

The study by Kellogg et al. (1994) indicates that Michigan is at risk in the area of pesticide leaching potential. It is not clear from the equation on pesticide leaching potential (explained in Appendix D) why certain regions of Michigan have a high potential for pesticide leaching whether farmers use pesticides which are particularly vulnerable to leaching, or whether the regions have in general a high level of pesticide use or whether the soils leach. To determine at least some of these uncertainties, it is necessary to establish the use of pesticide in Michigan. County level data is not available regarding pesticide use, however, the application of chemicals can be estimated from production data on fruits and vegetables, although no data is available for the actual application of chemicals on crops.

Pesticide use data is only available for fruit production in Michigan. Michigan farmers apply a variety of chemicals to their fruit fields, including tart cherries, sweet cherries, prunes and plums, peaches, grapes, apples, and blueberries. Some of the chemicals include insecticides (in 1,000 lbs per year): Petroleum distillate (1,400), Azinphos-methyl (150), Phosmet (135), and Chlorpyrifos (92). Other insecticides are Dimethoate with 15,000 lbs per year, Propargite with 62,000 lbs per year, and Endosulfan with 40,000 lbs per year. Applied fungicides include Captan (approximately 1,000 lbs per year), Sulfur (1,500), Chlorothalonil (150). Additionally, farmers use Benomyl with 15,000 lbs per year, Dodine with 59,000 lbs per year, and Ferbam with 52,000 lbs per year. Herbicides used extensively include Paraquat with 13,000 lbs per year, and Simazine with 23,000 lbs per year applied to fruits.

The potential damages from pesticides are well documented in a study by Kovach, et al (1992), in which the authors designed a method for the measurement of the environmental impacts of pesticides. The study was conducted for the purpose of providing a tool for farmers to compare the different pesticides available to determine which chemical has the lower environmental impact. The effects of pesticides were determined for the following categories: Farmworker Components (applicator effects, picker effects), Consumer Components (consumer effects, groundwater effects), and an Ecological Component (aquatic effects, terrestrial effects). For the purpose of this study, only groundwater effects and aquatic effects are summarized. Specifically, Kovach et al. took the leaching and surface loss potential of pesticides from the GLEAMS database, which also provided the necessary information on water half-life, pesticide solubility adsorption coefficient, and soil properties. "The variables that provided the best estimate of surface loss and leaching were then selected by this model and used to classify all pesticides into risk groups (large, medium, and small) according to their potential for leaching and surface loss" (Kovach, et al., 1992, p. 2).

For the calculation of the Consumer Component the researchers added consumer exposure potential and the potential groundwater effects.[51] The Ecological Component is composed of the aquatic effects and the terrestrial effects. Aquatic effects were

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[51] Consumer exposure is calculated by Kovach, et al. by multiplying the chronic toxicity of a pesticide and the average for pesticide residue in soil and plant surfaces (because plants and plant parts are consumed) and the "systemic potential rating of the chemical (the pesticide's potential to be absorbed by plants).

calculated by Kovach et al. by taking into consideration the chemical toxicity to fish and the surface runoff potential of chemicals, which takes into consideration the half-life of the pesticide in surface waters. Terrestrial effects were determined by the toxicity of pesticides to birds, bees, and "beneficial arthropods."

The resulting values represent individual effects and it is assumed that the higher the value, the more risk is involved in using a particular chemical. The resulting values for the Ecological Components cover many of the pesticides that Michigan farmers use on their fruits and vegetables. For example, Benomyl, a fungicide used on cherries, has a consumer component of 50 (the values of all fungicides covered in the study range from 3.1 to 50, with an average of 12.9), and an Ecological Component of 128.5 (the values range from 22 to 135.3). An example of an insecticide commonly used on fruits and vegetables in Michigan is the chemical Dimethoate, with a Consumer Component of 9.0 (range 2.5 to 29, with an average of 8.0) and an Ecological Component of 140.9 (range 22.5 to 165.1, average of 84.4). In the category of herbicides, the chemical widely used among others in Michigan is Paraquat. The value for the Consumer Component is 13 in a range of 3 to 13 (average 8.4), and the Ecological Component is 125 in a range of 26 to 125 (average 59.5).

Taken into consideration the discussion of the potential dangers to water quality through leaching and runoff of pesticides, it becomes evident, that Michigan displays a potential problem in the area of pesticide use, leaching, and runoff. As mentioned before, the regions of fruit production in Michigan is concentrated primarily along the western coast of the state. The potential for leaching is also particularly high in that area.

A.2 Pesticide Exposure

The exposure to pesticide is also demonstrated by the data set provided by ERS. Potential Pesticide Exposure (ERS Map 6) is included for the purpose of emphasizing that pesticides are a problem in the state of Michigan. The variable with the resulting map provides yet another way to look at pesticides and their potential damages to Michigan's environment. ERS calculated the variable of Potential Pesticide Exposure as pounds of active ingredients of pesticide applied, weighted by persistence and toxicity:

$PEI = \Sigma\ AI * 1 / LD_{50} * H$ 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 laboratory animals[52]
H = Half-life of the pesticides in the soil[53]

The variable is based on work by Heimlich and Ogg (1992) and Gianessi (1991). LD_{50} is an acute toxicity measure. The lower the LD_{50}, the higher the toxicity of the chemical. $AI * (1/LD_{50})$ results in the number of lethal doses. The multiplication factor H is the half life of the chemical. The shorter the period of time, the less the environment is exposed to the chemical. Thus, the multiplication of $AI * (1/LD_{50})$ weights the time duration of the chemical's existence in the environment, i.e. it accounts for persistence.

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[52] The lower the LD_{50}, the more toxic is the chemical.
[53] The shorter the half-life of the pesticide, the shorter the period of time, the soil is exposed to the pesticide.

As the authors acknowledge, the data set of potential pesticide exposure has several shortcomings. The calculations do not take into consideration chronic toxicity, fat solubility, and bio accumulation. Nevertheless, the national index map is heavily weighted towards the eastern coastal regions of the US, as well as the south east (Florida, Georgia, Alabama). The state of Michigan (Map K.6, Appendix K) shows that the area of the Saginaw Bay, central Michigan, and the western coastal regions have potential pesticide exposure.

Appendix B

Introduction to GIS and Case Study

Appendix B

B.1 Introduction to GIS

The Geographic Information System (GIS) is a computer-based system which provides a method of preparing, presenting, and interpreting data. It is designed to collect, store, and analize data where the geographic location is critical for the analysis of certain phenomena. The capability of GIS is most apparent in situations where especially large amounts of data cannot be manipulated manually. The data may be in the form of tables, addresses, or lists of names, which can be input into GIS, manipulated, and analized in a lss time-consuming and more cost effective manner (Aronoff, 1989, p.1). The capabilities include the mapping locations, e.g. the wells that are deeper than a certain depth in a certain county; condition, asking to display a characteristic (tax valuation, etc.) at a point in the map; trends, which involve production, population changes, etc. over time; patterns, which are predictive capabilities such as the calculation of the fragmentation of crop land patches in a certain area; and modelling, involving for example the calculation of a certain route of new highway with the lowest cost in terms of losses of prime farmland, wetlands, and housing, while minimizing the need for cutting forests, filling wetlands, etc. (Lusch, 1995, p 2).

The GIS has four classes of data: point (a well or town), line (stream or road), area (city of field), and volume (fertilizer or yield). Additionally, GIS allows for two different types of mapping; a vector based system and a raster based system. The data type requirements are different depending on the type of mapping chosen. For the vector

system, the point is a position, the line involves length but no width, and a polygon is the area and perimeter. For the raster system, the point is one cell, which may lose some precision depending on the size of the cell.[54] The line involves multiple cells joined at edges or corners, while the polygon is a group of adjacent cells joined at edges or corners.

In a vector system the topography can be completely described, including network linkages. It has also the advantage that the resulting map looks like a map, i.e. the graphics are clear, while the raster system is an aggregation of cells, which is best used for roads, and area data. However, the overlaying of maps is easier, since there is no possibility of fragmented polygons developing because all cell borders are coinciding. It is also a better system for the integration of remotely sensed imagery, e.g. satellite images or scanned photos (Lusch, 1995, pp. 4, 5).

The GIS processing cycle consist of the encoding of data into a base map, consisting of latitude, longitude, area, etc. and overlaying of supporting data, which can then be retrieved as complete maps. Following is the analysis process of the map and the storing, which can be displayed as needed.

The application of GIS includes many different facets, including agricultural land use planning, forestry and wildlife management, geology, archaeology, municipal application such as zoning, and global scale application such as the global environmental status. Thus, the applications of GIS are numerous and diverse. For example, with the use of GIS, a coincidence factor, such as the location of soil erosion and land use can be

[54]One cell is filled with one data set, i.e. only crop land area can be filled in one cell, even though there may be other variables of interest.

determined. The following case study is an example on the use of soil conservation planning through GIS and microcomputer technologies.

B.2 Case Study: Soil Conservation Planning at the Watershed Level

The case study, conducted by Mellerowicz, et. al (1995, p 194 - 200), involves the soil conservation at the watershed level using the Universal Soil Loss Equation (USLE) with GIS and microcomputer technologies. Specifically, a system was designed to integrate data bases. The case study was conducted within the Black Brook Watershed of north western New Brunswick, Canada. The USLE was used in order to predict annual soil ereosion rates and GIS was used with the purpose of characterizing the spatial distribution of the risk of soil loss by water on agricultural land. The purpose of the study was to develop and apply a technique which integrates resource information on soils, climate, and land use, with GIS technologies to assist in soil and water conservation planning at the watershed level.

Specifically, the study was conducted to classify the Black Brook Watershed in terms of predicted current annual soil loss resulting from water erosion. Additionally, it identified the areas in the watershed for which low cost changes in soil management practices (chisel plowing, winter cover, and contouring) could reduce the soil loss to tolerable levels. Furthermore, the areas were identified for which more extensive solutions are required to reduce soil loss.

The USLE was used to classify the watershed in terms of predicted annual soil loss rates. Rainfall determination, as well as the erodibility factor, including of organic matter in the soil, permeability, soil structure, and contents of sand, silt and clay, was determined.Furthermore, the topography (slope segments and slope length) was calculated using USLE and cropping was determined as well as the support practices for individual fields.

Appendix C

Calculations of ERS's Potential Environmental Variables

Appendix C

Explanation of ERS's Data Set

The unweighted ERS data for the potential environmental problems in the state of Michigan were extracted from the national data base and mapped using GIS. The variables with the data include:

(1) Potential soil productivity loss
(2) Potential nitrogen runoff
(3) Potential windblown dust
(4) Potential sediment delivery
(5) Potential pesticide leaching
(6) Potential nitrogen leaching
(7) Potential for filter strips
(8) Potential pesticide exposure (explained in Appendix A)
(9) Threatened and endangered species
(10) Potential habitat improvement

Environmental Problems	**Ranges for Indices**			
	Range 1	Range 2	Range 3	Range 4
Soil Productivity Loss	data not available	0.01-1.19	1.2-2.59	2.6-100
Nitrogen Runoff	data not applicable	0.01-71.46	71.47-76.11	76.12-100
Windblown Dust	data not applicable	0.01-2.95	2.96-7.14	7.15-100
Sediment Delivery	data not applicable	0.01-0.69	0.7-5.58	2.59-100
Pesticide Leaching	data not applicable	0.01-2.01	2.02-7.07	7.08-100
Nitrate Leaching	data not applicable	0.01-5.76	5.77-12.09	12.1-100
Filterstrips	data not applicable	0.01-3.43	3.44-6.85	6.86-100
Pesticide Exposure	data not applicable	0.01-1.48	1.49-6.02	6.03-100
Endangered Species	data not applicable	0.01-7	7.01-11	11.1-100
Wildlife Habitat	data not applicable	0.01-69.18	69.19-78.92	78.93-100

The data set also includes a composite index which was not used for the purpose of this study. The composite index provides an aggregate measure of agricultural environmental performance, which could then be combined with other factors, either farm or economic. As an example, Heimlich (1994, p.21) cites the combination of the composite index with the distribution of farm program payments to show areas with high relative environmental problems that also receive high levels of agricultural program payments.

By the distribution of the index, it becomes apparent that the ERS had determined that the index of 2.60 to 100 (from a range of zero to 100) is adequate to use the index to identify potential agro-environmental problem. The same skewed data is shown on all potential national environmental problems. The raw data (not normalized) was extracted from the national data. The normalization process forces at least one county to have an index of 0 and one to have an index of 100, even though the data may be skewed toward the high or low range of the index.

C.1 Potential Soil Productivity Loss

The total erosion from sheet, rill, and wind erosion was converted from tons per acre per year to inches per year using the soil bulk density ratio. The resulting soil loss per inch is divided into the top soil depth that is associated with each NRI sample point. The resulting value measures the remaining years before the topsoil is depleted at current erosion rates. In order to reflect the economic value of the soil, the inverse of the years of topsoil remaining at current erosion rates is multiplied by the soil-specific productivity adjusted dryland cash rent.[55] The ERS national map is included which represents soil

[55]The soil-specific productivity adjusted cash rent was calculated from average cash rents, adjusted for differences in relative productivity of the soil occurring at 1982 NRI sample points.

productivity loss as an unweighted variable (Map J.4, Appendix J). Therefore, thinner soils with higher erosion rates have fewer year of productivity than thinner soils with low erosion rates. Thus, ERS calculated the variable of Potential Soil Productivity Loss which is presented as follows:

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

where

SDI = Soil Degradation Index
TD = Topsoil depth, measured in inches
PE = Potential erosion from water or wind in inches per year, using the soil bulk density[56]
R = Soil-specific productivity adjusted dryland cash rent, calculated from average county rents and adjusted for differences in relative productivity of the soils occurring at the 1982 NRI sample points.

The variable was weighted by the value of the lost soil, represented by productivity-adjusted dryland cash rent. "Weighing by the cash rent value de-emphasizes areas with less valuable soils in favor of erosion on the highly productive soils" (Heimlich, 1994).

C.2 Nitrogen Runoff

Runoff nitrogen loss was calculated as the sum of runoff-extracted nitrogen from crops. Runoff-extracted nitrogen is defined as the product of soil soluble nitrogen in the top centimeter of the soil and runoff volume. Soil soluble nitrogen and excess nitrogen from fertilizer accounted for the concentration of nitrogen in soil pore water (5 mg/l),

[56] This measures the number of years it takes for the topsoil to be depleted at current erosion rates.

determined using and the porosity, (soil bulk density) included in the SOILS5 database.[57] As ERS calculated the variable, potential nitrogen runoff depends on the amount of residual nitrogen above crop requirements, as well as the infiltration and water-holding capacity of the soils.

Essentially, the two determining factors for the potential of nitrogen runoff are the porosity of the soil and the excess nitrogen from fertilizer inputs. The more porous the soil in a given region, the higher the potential nitrogen runoff; and, the more excess nitrogen in soils from fertilizer, the higher the potential nitrogen runoff. Excess nitrogen was based on corn, wheat, and cotton crop requirements for growing at each sample point. The equation does not account for for which variable contributes the most to the resulting value of potential nitrogen runoff. Animal manure was not considered as a source of nitrogen in the ERS equation.

Runoff Nitrogen (RON) was calculated as follows:

$$RON = 0.443 * CSOIL * R * 0.2 * 10^{-2}$$

Where

$$CSOIL = (QPORE + XNFERT * 0.05 * 73) / 0.01 * (QSOIL + 1)$$

QPORE	=	0.1 * CPORE * POR
CPORE	=	Concentration of Nitrogen 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 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.[58]

[57]Soil bulk density is the total mass of soil, water, air, etc. in a representative volume of soil.

[58]Additionally, NRI sample points were identified representing fields within 100 feet of water bodies as having the potential for filterstrips.

C.3 Sediment Delivery

On a national level, the potential sediment delivery problem is concentrated primarily in Missouri, Iowa, Kentucky, Tennessee, North and South Carolina, and Virginia (Map K.7, Appendix K). The potential for sediment delivery is relatively low when compared to the problem areas nationally. However, there are problems of potential sediment delivery in the state of Michigan. Although the topography of Michigan is level, there are hills in the western Upper Peninsula and the northern Lower Peninsula. Surprisingly, the potential sediment delivery is concentrated in the southern and southwestern counties of the state, which exhibit low slopes according to a topography map generated by Eichenlaub et al. (1990), but which do have the bulk of crops. Counties in the western part of the Upper Peninsula, which display a potential for sediment delivery and have a sloped landscape, are an exception.[59]

The results can partially be explained by the equation ERS used to determine the sediment delivery index. In the equation, the land coefficient for cropland was weighted more heavily than the coefficient for pasture land and forests. In Michigan, crop production is partially concentrated, among other areas, in the counties listed for sediment delivery to lakes and streams. Additionally, the slopes in the counties were taken into consideration, as was the distance from the crop, pasture, and forest lands to the nearest surface water.

ERS's sediment delivery calculations were based on Shanholz and Kleeve (1992) who calculate delivered sediments by multiplying gross erosion by a delivery ratio, which

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[59] The amount and average slope of intervening land uses were proxied by the acreage and average slope of cropland, pasture, and forest land in each NRI polygon.

was based on land cover, flow path length, and slope. The sediment delivery ratio increases as the distance to the nearest body of water decreases. More weight (increasing delivery ratio) is given to cropland compared to pasture and nonagricultural forest land. Similarly, as the slope of the land increases, the soil delivery ratio also increases. The equation was calculated as follows:

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

Where

DR = Delivery Ratio
k = land cover coefficient, which is categorized into cropland (=0.4233), pasture (=0.71), and nonagricultural woodland (=1.1842)
d = the flow path length from the field to the nearest stream
S_f = slope function = $e^{-n(S + SO)} + S_{fmin}$
where
n = 16.1
SO = 0.057
S_{fmin} = 0.6
S = slope percent of the land use segment in the flow path

DR was calculated over all land use and slope segments in the 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" (Heimlich, 1994, p. 49). Instead, as a proxy, ERS used the value for the acreage and calculated average slope of cropland, pasture, and forestland for each NRI polygon. The authors assumed that the resulting values would, on average, apply to flow path from each NRI sample point in the polygon.

C.4 Nitrate Leaching

ERS did not include calculations for nitrate leaching, therefore, the groundwater vulnerability index for nitrate leaching, based on work by Williams and Goss, and excess nitrogen calculations were developed by Wen Huang (1992), were used. The excess nitrogen calculations were based on three primary factors: (1) the propensity of the soils to leach nitrates (and pesticides), (2) the amount and timing of rainfall which is required to carry the nitrates through the soil and to the groundwater, and (3) the extent of chemical use. Although Kellogg, et al acknowledges that vulnerability measures must be site specific information such as soils, climate, and chemical use. Since the study was done on a national level, the calculations had to be "general enough to allow a consistent calculation for all areas of the country." The 1982 NRI and associated soil data bases provided the necessary site specific data on soil properties and soil types. General climate data was attributed to the NRI sample points using GIS and chemical use was inferred on the basis of crops grown, using chemical use data by crop and state taken from Resources for the Future (Kellogg, et al., 1994, p. 294).

The ground water vulnerability index for nitrogen (GWVIN) was calculated as follows:

$$GWVIN_i = PF_i * EXCESSN_i$$

Average area index:

$$= \frac{S^{N}{}_{i=1}\ EXPAND_i * GWVIN_i}{S^{N}{}_{i=1}\ EXPAND_i}$$

Where

i	= 1,2,3,...,N NRI sample points in a specific geographical area
$EXCESSN_i$	= estimates of excess nitrogen fertilizer applied per area at each NRI sample point
$EXPAND_i$	= expansion factor for an NRI sample point
PF_i	= percolation factor calculated for each NRI sample point

Excess nitrogen ($EXCESSN_i$) per acre is the difference between the amount of nitrogen applied from fertilizer (excluding nitrogen from animal manure, but taking into account nitrogen that was fixed by previous leguminous crops) and the amount of nitrogen taken up by the crops and removed from the field. County level calculations for excess nitrogen fertilizer (used as the variable $EXCESSN_i$) applied to corn, wheat, and cotton were compiled by Huang, Economic Research Service, USDA. All calculations were made in pounds of nitrogen per unit of area. The results were incorporated into the 1982 NRI sample points by matching crop type by county:

$$N_e = N_f - (N_g + N_s - N_l)$$

Where

N_e	=	Excess nitrogen fertilizer applied
N_f	=	Amount of commercial nitrogen fertilizer applied
N_l	=	Nitrogen credit from previous legume crops
N_g	=	Nitrogen content of harvested portion of crop
N_s	=	Nitrogen content of other plant material removed from field

The percolation factor (PF) represents the average annual percolation of water through the soil to the root zone. The amount of water that percolates through the root zone is important in the calculation of the amount of nitrate leached. The level of water percolation is determined by a balance between "gains in soil water by rainfall, or irrigation and losses from the soil water storage reservoir from crop water use and evaporation" (William and Kissel, 1991, p. 59). William and Kissel (1991) developed the original nitrate leaching index which was subsequently modified by Kellogg, et al. to integrate an adjustment for irrigation into the equation:[60]

PF = LI + I + Adjustment for irrigation

where

LI = SI * PI
$SI = [(2PW) / P]^{1/3}$
$PI = (P - 0.4s)^2 / (P + 0.6s)$
PW = the sum of fall and winter precipitation
P = the annual precipitation
s = parameter for the soil hydrologic group.[61]

SI represents the Seasonal Index, which expresses the seasonal precipitation effects as average monthly precipitation. PI is an estimate of average precipitation in inches , and P represents the average annual rainfall in inches. The coefficients 0.4 and 0.6 are adjustment factors (Williams and Kissel, 1991, p. 80).

Nongrowing seasons were taken into consideration when calculating the index by adding the value 5 at each NRI sample point such that non-growing periods are weighted more than growing period. Specifically, the value 5 was added at each NRI sample point where the 1982 data indicated that more than half of the area was watered by irrigation.

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[60] Williams and Kissel (1991) outline the roles of some of the most important factors interacting with the level of water percolation and the subsequent level of nitrate leaching. Furthermore, simulated percolation amounts were characterized by the average percolation as well as the variation in percolation at various agricultural locations in the US. The results were intended to assist in evaluating the leaching potential of nitrates.
[61] Precipitation data was imputed to NRI sample points based on their proximity to one of 7,744 weather stations. Average precipitation was based on EarthInfo CD ROM from the year 1988.

C.5 Pesticide Leaching

The Groundwater Vulnerability Index for Pesticides (GWVIP)

$$GWVIP_i = S^4{}_{j=1}\ Pf_j * PESTWT_{ij} * LEACHWT_{ij}$$

The average area index is calculated in a similar fashion as the Nitrate Vulnerability Index:

$$= \frac{S^N{}_{i=1}\ EXPAND_i * GWVIP_i}{S^N{}_{i=1}\ EXPAND_i}$$

Where

I	=	1,2,3,...,N NRI sample points in a specific geographical area
j	=	1,2,3,4 pesticide leaching classes (large, medium, small, extra small)
$EXPAND_i$	=	expansion factor calculated for each NRI sample point
Pf_i	=	percolation factor calculated for each NRI sample point
$PESTWT_{ij}$	=	pesticide use-weights derived from percent area treated data calculated for each pesticide leaching class at each NRI sample point.
$LEACHWT_{ij}$	=	leaching weights reflecting relative amounts of pesticide leaching below the root zone for each pesticide leaching class and at each NRI sample point.

The NRI sample point information must be extrapolated over a representative region in acres (the variable EXPAND), which then can be averaged over small geographical areas (e.g. watershed, soil types) which may intersect numerous counties. Additionally, an expansion factor (EXPAND) was included and was defined as the acres which one NRI sample point represents.

The following summary of data collection procedures for the potential pesticide leaching variable in the data set by the Economic Research Service was based on the

Groundwater Vulnerability Index developed by Kellogg et al. (1992), who extended the Soil-Pesticide Interaction Screening Procedure, a field level screening procedure used by Soil Conservation Service to provide technical assistance to farmers in order to calculate a pesticide index. The procedure as defined by the Soil-Pesticide Interaction Screening Procedure, is based on a 4 by 4 matrix which categorizes potential pesticide loss by combining four pesticide leaching classes and four soil leaching classes, as shown in Table C.1. "Pesticide loss potentials range from 4, indicating essentially no pesticide loss, to 1, which represents situations where 80% or more of the pesticide might leach past the root zone.[62]

Table C.1: Pesticide Loss Potentials (as defined by the Soil-Pesticide Interaction Screening Procedure)

Soil Leaching Class	Pesticide Leaching Class			
	Large	Medium	Small	Very Small
High	1	1	2	3
Intermediate	1	2	3	4
Low	2	3	3	4
Very Low	3	3	4	4

[62]The pesticide loss potential calculations were based on the ground water leaching model (GLEAMS) to calculate pesticide leaching below the root zone for almost 41,000 combinations of pesticide and soil leaching properties (Kellogg, et al., 1994, p. 294). GLEAMS is a computer model which simulates leaching and surface loss potential of pesticides in a variety of different soils. Additionally, GLEAMS uses statistical methods to evaluate "the interaction between pesticide properties (solubility, adsorption coefficient, and half-life) and soil properties (surface horizon thickness, organic matter content, etc.)" (Kovach, et al., 1992, p. 2).

The Groundwater Vulnerability Index for Pesticides (GWVIP) is a function of soil leaching potential, pesticide leaching potential, precipitation, and chemical use (type of chemical, rather than amounts). Chemical use at each NRI sample point was inferred on the basis of crops grown using chemical input (fungicides and herbicides) use data by crop and state developed by Gianessi and Puffer (1992, 1990). The fungicide use in U.S. crop production was compiled through Resources For the Future (RFF) by Gianessi and Puffer using various surveys and reports.[63] RFF used two coefficients for the calculation of fungicide use: the percent of acres treated and the average annual application rate of active ingredients per acres treated. The fungicide coefficients were then multiplied by the estimate of crop acreage from the 1987 Census of Agriculture which estimated the total number of treated acres and total pounds of active ingredients used by state and crop. The herbicide data compiled by RFF was conducted in the same manner (Gianessi and Puffer, 1990)

The resulting index represents a weighted average index of the pesticide leaching scores for each NRI sample point. According to Kellogg, et al (1994), a weighted average is necessary due to possible variations of the expansion points associated with each NRI point among the NRI sample points within even a small geographic area. Additionally, an expansion factor was included and was defined as the acres which one NRI sample point represents.

[63] Surveys and reports used in the study include the National Agricultural Statistics Service, U.S. Cooperative Extension Services from individual states, Pesticide Benefit Assessments from USDA's National Agricultural Pesticide Impact Assessment Program, and state use reports.

The soil leaching factor was found in the Soil-Pesticide Interaction Screening Procedure. The weights, as defined by the screening procedure (Table C.2), had to be changed to relative weights to allow for the aggregation over several chemicals with different leaching potentials at a single NRI sample point. The likely reason for the relative weighing may be that the sample points are in a region which represents an area of higher leaching potential. For example, the very small pesticide leaching class is given no weight in the very low soil leaching class. The same is true in the intermediate and low soil leaching classes. The weights are considerably changed from the screening procedure where the very small pesticide leaching class was still given some weight in the intermediate, low, and very low soil leaching class. The relative weights were assigned as follows:

Table C.2: Weights Used To Aggregate Over Chemicals And NRI Sample Points

Soil Leaching Class	Pesticide Leaching Class			
	Large	**Medium**	**Small**	**Very Small**
High	**0.825**	**0.619**	**0.206**	**0.011**
Intermediate	**0.619**	**0.206**	**0.050**	**0**
Low	**0.206**	**0.050**	**0.002**	**0**
Very Low	**0.011**	**0.002**	**0**	**0**

These weights were obtained using statistics from GLEAMS simulation which was used to derive the Soil-Pesticide Interaction Screening Procedure. The Soil-Pesticide screening procedure matrix is a set of relative weights which "represent the approximate maximum amount of pesticide that might leach below the root zone." Leaching potential values were then assigned to each of the combinations of soil leaching and pesticide leaching classes in the above table.

PESTWT was derived by Kellogg et al. using the percent of the area treated with pesticides.[64] Estimates for pesticide use at each NRI sample point were based on the relation between pesticide use by crop and state. A value for PESTWT was determined for each of the four pesticide leaching classes "at each NRI sample point by summing over the percent area treated for all the chemicals within the same pesticide leaching class" (Table C.2).

C.6 Potential for Filterstrips - Study by Lee and Lovejoy

A data set from Lee and Lovejoy (1994) studies the characteristics of land area for riparian buffers to control agricultural nonpoint pollution through a GIS approach. The authors used a spatial approach because the data from available sources such as the agricultural census, lack the spatial linkage to relate data to physical features, such as elevation. The authors overlaid land use data (cropland, pasture, other agricultural land, forest, forest wetland, other wetland, urban, commercial, industrial, military reserves, water bodies, etc.) from the Land Use Data Analysis (LUDA) developed by the U.S. Geological Service (USGS) with USGS stream data and digital elevation data for the U.S., as well as for the state of Indiana and the county of Tippicanoe in Indiana, to

---

[64] Resources for the Future profiled 84 crops in one or more of the lower 48 states, with data sources reaching throughout the years 1987 to 1991. Each pesticide was assigned to one of four pesticide leaching classes (large, medium, small, and extra small). Almost 170 pesticides were used in the analysis, including 93 herbicides, 24 fungicides, and 51 insecticides.

demonstrate the improvement of resolution for the purpose of determining the possibilities for filter strips to reduce agricultural nonpoint pollution.

Digital elevation maps from USGS were then used to calculate slopes of the areas for filter strips. Elevation data was categorized between slopes 0 to 12 percent (rather than including higher slopes) because agricultural lands are generally located in lower sloped areas. Specifically the categories of 0 to 2%, 2 to 4%, 4 to 6%, 6 to 9%, 9 to 12%, and slopes greater than 12%. Specifically, the estimates of agricultural cropland were derived by overlaying land use, stream defined buffers, elevation, and geo-political boundaries on maps, which were then integrated into the county level.

C.7 The Potential for Filterstrips - ERS Data Set

The ERS did include data for the Potential for Filterstrips, although no calculations were provided. The resulting national map reveals that a relatively large region in California, and the midwest of the country has a high potential. Michigan is included with most of the counties containing cropland within 100 feet of a water body.

C.8 The Potential for Wildlife Habitat Improvement

The approach taken by ERS describes wildlife as a series of layers consisting of different types of vegetation. Six layers of habitat were identified, consisting of water surface, terrestrial subsurface, understory, shrub midstory, tree bole, and tree canopy. Areas with more layers are generally more capable of supporting a greater diversity of species due to the larger number of available habitats.

In order to determine the layers of habitat, six land covers were considered: (a) fruits, nuts and other horticulture, (b) row crops, small grains, and vegetables, (c) grass and hayland, (d) grass and pasture land, (e) rangeland, and (f) forest land. Each layer is rated "using variables describing the condition of the layer, such as tree canopy density and rangeland condition" because the condition of the layer affects the habitat. The resulting Habitat Structure Index represents the percent of maximum potential habitat structure available. Additionally, the difference between the current cropland cover and grass was calculated in this index, which measures the potential improvement in habitat if the land were idled (or the decline in habitat if the land was taken under crop production).

Distances to land cover, i.e., wetland, cropland, etc. were also incorporated into the variable in order to calculate a Habitat Diversity Index. Both indices were multiplied to generate a Habitat Index. Additionally, the change in habitat value which has occurred, or will occur due to a restoration of permanent cover in the Conservation Reserve Program, is reflected by the difference between the Habitat Index in cropped use and in CRP cover.

The impact on endemic wildlife species was measured including the number of endangered species from a study conducted by the Soil Conservation Service and the Forest Service. Specifically, counties in which a species are known to be present or which have an appropriate habitat structure with no known populations, were added. The criteria for the indicator were species threatened by agricultural development.

Appendix D

Explanation of Federal Commodity Program Components

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Explanation of Federal Commodity Program Components

D.1 Loan Deficiency

Deficiency payments are payments made to farmers who partake in the feed grain programs which consist of corn, sorghum (not produced in Michigan), oats and barley, as well as wheat, rice, or upland cotton programs (again, rice and cotton are not part of the Michigan agricultural production). The deficiency payments rate is the difference per unit of crop production is determined by the difference between a target price and the market price (or loan rate), whichever difference is smaller (Anderson, 1994, p. 5).

D.2 Feed Grains And Barley Deficiency Payments

Feed grain and barley assessment deficiency programs are positioned together in nearly all publications regarding the explanation of the components of the federal commodity programs. Specifically, corn accounts for nearly 75 percent of all feed grains harvested acres. Throughout the history of the feed grain deficiency programs, qualification for price support and income supplements has been associated with production acre limitations, as well as more recent compliance with certain soil conservation and wetland practices. The Wheat Deficiency Program operates essentially in the same manner as the feed grain and barley deficiency programs.

D.3 National Wool Act Payments

The Wool Act began in 1954 as congress realized that domestic wool and mohair are essential commodities. Congress established the national wool and mohair production did (and does) not meet the domestic demand for the product and the following incentive program was instituted as a means to raise domestic production of the commodities. The National Wool Act was determined to increase production to 300 million pounds "which was to be used as a measure of our national security and in promotion of the general economic welfare." The payments to producers in any year are limited to 70 percent of the total number of the import duties collected on imported wool and wool productions during that year (Davis, et. al, Papers on the farm bill, Internet Download). The current situation is such that Congress decided to phase out the incentive payments over 1994 and 1995, with repeal of the national Wool Act. Wool producers will receive 75 to 50 percent of their calculated payments for the 1994 and 1995 marketing years. Instead, a nonrecourse loan program will be offered by the USDA "as a marketing tool during 1994 and 1995" (Davis, et. al).

D.4 Dairy Termination Program Payments

The dairy termination program originated due to a growing surplus in of dairy products. In response to this increase in dairy products and increasing government costs, the 1981 farm bill terminated the support price for dairy on a parity basis. Additionally, in an effort to reduce both milk surplus and budget concerns, a voluntary milk supply control program was initiated. Furthermore the 1985 farm bill authorized the dairy termination program, which paid dairy farmers to end dairy farming for a period of five years. The 1990 farm bill fixed the support level to a minimum of $10.10 per hundredweight (Cropp and Stephensen, 1994, , Papers on the farm bill, Internet Download).

D.5 Forestry Incentive Program (FIP)

The Forestry Incentive program is administered by the ASCS and the Forest Service provides technical assistance. The program was instituted in 1975 which provides cost-sharing for up to 65 percent of tree planting "and timber stand improvement for private forest lands of no more than 1,000 acres." The maximum payment for each forest land owner is $10,000, however, average payments are approximately $2,500, with about 5,500 forest land owners participating in the program in 1993 (Anderson, ed., 1994. p.168).

D.6 Water Bank

The Water Bank program makes annual per acre payments to landowners who "agree not to burn, drain, fill, or otherwise destroy the character of the enrolled wetland acres" (Anderson, ed., 1994, p.192). Further federal cost-sharing payments are available for installing conservation practices which are intended to sustain the vegetative cover, control erosion, improve wildlife habitat, conserve surface water, as well as to manage bottomland hardwoods. The Water Bank Program is administrated by the Agricultural Stabilization and Conservation Service (ASCS). Congress terminated the Water Bank program in USDA's FY [fiscal year] 1995 budget. "Payments to farmers will end as their 10-year contracts expire, beginning in 1995. However, Congress will consider the possibility to roll the Water bank wetlands into the Wetland Reserve Program (WRP), but wetlands may not be eligible for enrollment (Anderson, ed., 1994, p.192).

D.7 Livestock Emergency Assistance

The Commodity Credit Corporation program provides assistance to eligible livestock producers by sharing the cost of feed purchased "to replace the farm's normal production and feed purchases in quantities larger than normal" because of an emergency (United States Department of Agriculture, 1991, p. 143). This provision requires the Secretary of Agriculture to declare an area a natural disaster before implementation takes place.

In addition, there are certain minor components of the commodity programs which are Extended Farm Storage, Extended Warehouse Storage, Interest Penalty Payments, Milk Marketing Fee, and Market Gains. The definitions for these components can be found by contacting the local Agriculture Stabilization and Conservation Service office.

Appendix E

Econometric Equations

E.1 Regression Equation for CRP payments and the Composite Index

```
Dependent variable: CRP91
===============================================================================
Command:  LS CRP91 C COMP
Equation: CRP91=C(1)+C(2)*COMP
Sample:   1  -    83
===============================================================================
@R2      0.109337    @SE      272993.7    @SSR     6.04E+12    @NCOEF          2
@RBAR2   0.098341    @LOGL   -1155.688    @DW      2.004039    @REGOBS        83
===============================================================================
C(1) = -315631.1    C(2) =  3715.103
===============================================================================
```

E.2 Regression Equation for CRP payments and Potential Surface Water Problems (Potential Nitrogen Runoff (nrununw), Potential for Filterstrips (filtmap), and Potential Sediment Delivery (delsed)

```
Dependent variable: CRP91
===============================================================================
Command:  LS CRP91 C NRUNUNW FILTMAP DELSED
Equation: CRP91=C(1)+C(2)*NRUNUNW+C(3)*FILTMAP+C(4)*DELSED
Sample:   1  -    83
===============================================================================
@R2      0.403642    @SE      226192.6    @SSR     4.04E+12    @NCOEF          4
@RBAR2   0.380995    @LOGL   -1139.041    @DW      2.068794    @REGOBS        83
===============================================================================
C(1) =  10867.29    C(2) = -109.0787    C(3) =  55482.80    C(4) =  439591.3
===============================================================================
```

E.3 Regression Equation for CRP payments and Potential Groundwater Problems (Potential Nitrate Leaching (gwatunw), Potential Pesticide Leaching (gwvippt)

```
Dependent variable: CRP91
===============================================================================
Command:  LS CRP91 C GWATUNW GWVIPPT
Equation: CRP91=C(1)+C(2)*GWATUNW+C(3)*GWVIPPT
Sample:   1  -    83
===============================================================================
@R2      0.269513    @SE      248771.0    @SSR     4.95E+12    @NCOEF          3
@RBAR2   0.251250    @LOGL   -1147.460    @DW      1.846510    @REGOBS        83
===============================================================================
C(1) =  23339.54    C(2) =  128873.2    C(3) = -31197.30
===============================================================================
```

E.4 Regression Equation for CRP payments Potential Erosion Problems (Windersion (windunw). Potential Soil Productivity Loss (erosfin)

```
Dependent variable: CRP91
==============================================================================
Command:  LS CRP91 C WINDUNW EROSFIN
Equation: CRP91=C(1)+C(2)*WINDUNW+C(3)*EROSFIN
Sample:   1  -    83
==============================================================================
@R2     0.158188    @SE      267055.1    @SSR     5.71E+12    @NCOEF        3
@RBAR2  0.137143    @LOGL   -1153.347    @DW      1.949727    @REGOBS      83
==============================================================================
C(1) = -3514.153    C(2) = -41042.25    C(3) =  392483.8
==============================================================================
```

E.5 Regression Equation for CRP payments and Manure Production

```
Dependent variable: CRP91
==============================================================================
Command:  LS CRP91 C TOTMANUR
Equation: CRP91=C(1)+C(2)*TOTMANUR
Sample:   1  -    83
==============================================================================
@R2     0.276538    @SE      246038.8    @SSR     4.90E+12    @NCOEF        2
@RBAR2  0.267607    @LOGL   -1147.059    @DW      1.725758    @REGOBS      83
==============================================================================
C(1) =  15823.08    C(2) =  0.023580
==============================================================================
```

E.6 Regression Equation for CRP payments and Fruit and Vegetable Production (fruit, vegs)

```
Dependent variable: CRP91
==============================================================================
Command:  LS CRP91 C FRUIT VEGS
Equation: CRP91=C(1)+C(2)*FRUIT+C(3)*VEGS
Sample:   1  -    83
==============================================================================
@R2     0.016390    @SE      288672.1    @SSR     6.67E+12    @NCOEF        3
@RBAR2 -0.008200    @LOGL   -1159.807    @DW      1.839250    @REGOBS      83
==============================================================================
C(1) =  146665.6    C(2) = -7.486562    C(3) =  12.10000
==============================================================================
```

E.7 Regression Equation for CRP payments Potential Wildlife Habitat Improvement (hidex)

```
Dependent variable: CRP91
==========================================================================
Command:  LS CRP91 C HIDEX
Equation: CRP91=C(1)+C(2)*HIDEX
Sample:   1  -    83
==========================================================================
@R2      0.123072    @SE      270880.6    @SSR     5.94E+12    @NCOEF          2
@RBAR2   0.112245    @LOGL   -1155.043    @DW      2.001607    @REGOBS        83
==========================================================================
C(1) = -121462.3    C(2) =   5684.547
==========================================================================
```

E.8 Regression Equation for CRP Payments and Threatened and Endangered Plant and Animal Species

```
Dependent variable: CRP91
==========================================================================
Command:  LS CRP91 C SPECIES
Equation: CRP91=C(1)+C(2)*SPECIES
Sample:   1  -    83
==========================================================================
@R2      0.010510    @SE      287740.9    @SSR     6.71E+12    @NCOEF          2
@RBAR2  -0.001706    @LOGL   -1160.054    @DW      1.849973    @REGOBS        83
==========================================================================
C(1) =  185916.1    C(2) = -1500.914
==========================================================================
```

E.9 Abbreviations of Potential Environmental Problem and Agricultural Production Data

FIPS	Federal Information Processing Code
MLRA	Major Land Resource Area
HYDROS	Hydrological units boundaries (watershed boundaries)
UKEY	Combination of FIPS, MLRA, and HYDROS
FLOODEX	Potential Flood Peak Reduction weighted by Watershed Population
SOILDEX	Potential for Soil Productivity Loss weighted by Dryland Cash Rent per Year
GWNDEX	Potential Nitrate Leaching weighted by Population using Groundwater
GWPDEX	Potential Pesticide Leaching weighted by Population using Groundwater
FILTDEX	Potential for Filter Strips weighted by Watershed Population
DELDEX	Potential Sediment Delivery, weighted by Watershed Population
DELSED	Potential Sediment Delivery, not weighted
HIDEX	Potential Wildlife Habitat Improvement, not weighted
ENDEX	Potential for Threatened and Endangered Species
WINDEX	Potential Windblown Dust weighted by County Population
NRUNDEX	Potential Nitrogen Runoff weighted by Watershed Population
EROSFIN	Potential for Soil Productivity Loss, not weighted
PESTEXP	Potential Pesticide Exposure, not weighted
GWVIPPT	Potential Pesticide Leaching, not weighted
COMPDEX	Composite, all Indices, weighted by Appropriate Populations and Values Proxying for Damages
COMPDEXLN	Composite, all Indices Except Nitrogen Runoff weighted by Appropriate Populations and Values Proxying for Damages
COMPWILD	Composite, Wildlife Indices (Sums across Habitat Structure and Endangered Species Indices
COMPWAT	Composite, Water Quality Indices (Sums across Sediment Delivery, Filter Strips, Nitrogen and Pesticide Leaching Indices, Weighted by Appropriate Populations
COMPWATLN	Composite, Water Quality Indices Except Nitrogen Runoff
COMPSOIL	Composite, Soil Erosion Indices (Sums across Soil Productivity Loss and Windblown Dust Indices, weighted by Appropriate Population or Rental Value
FLOODUNW	Potential Flood Peak Reduction not weighted
WINDUNW	Potential Windblown Dust not weighted
NRUNUNW	Potential Nitrogen Runoff not weighted
FILTMAP	Potential for Filter Strips not weighted
GWATUNW	Potential Nitrate Leaching not weighted
COMP	Composite of all Agro-Environmental Variables

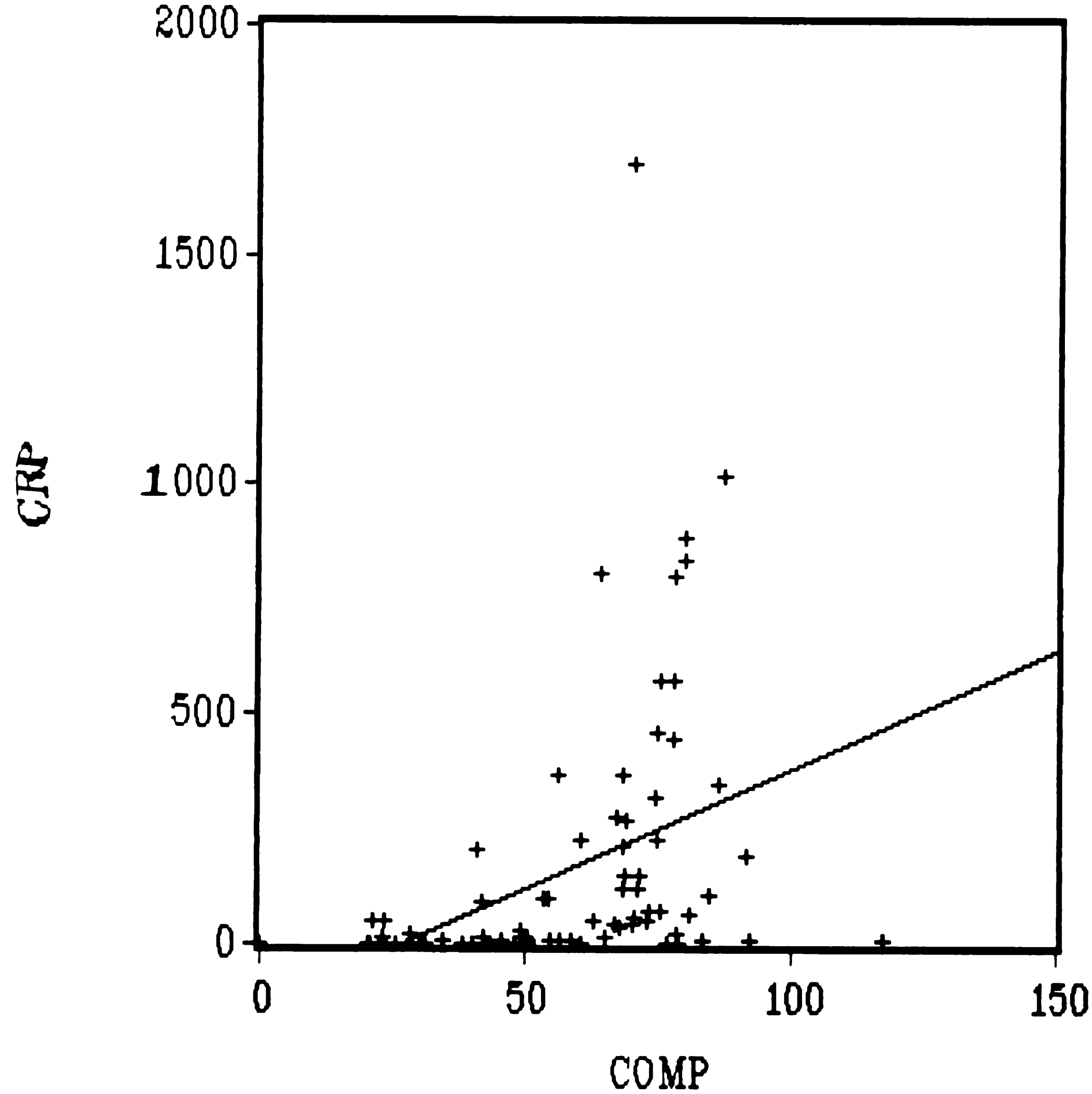
CRP1991	CRP Payments per county in 1991 in Michigan
TOTFAR	Total Commodity Program Payments per County in Michigan
FRUIT	Planted Fruit Acres per County in Michigan
VEGS	Planted Vegetable Acres per County in Michigan
TOTMANUR	Total Manure Production in Pounds per County in Michigan
SPECIES	Number of Threatened and Endangered Plant and Animal Species per County in Michigan

E.10 Correlation Coefficients

	CRP91	TOTALFAR	DELSED	ENDEX	EROSFIN	FILTMAP	GWATUNW	GWVIPPT	HIDEX	PESTDEX	SPECIES	WINDUNW	NRUNUNW	TOTMANUR	CROPS	FRUIT	VEGS
CRP91	1	0.71	0.52	0.3	0.39	0.49	0.49	0.08	0.35	-0.06	-0.1	0.2	-0.02	0.5	0.6	-0.07	0.07
TOTALFAR		1	0.34	0.21	0.39	0.54	0.6	0.11	0.6	-0.09	-0.05	0.43	-0.03	0.78	0.95	-0.02	0.2
DELSED			1	0.46	0.62	0.27	0.43	0.21	0.23	0.17	0.16	0.16	-0.07	0.3	0.27	0.16	0.07
ENDEX				1	0.19	0.17	0.36	0.09	0.18	-0.07	0.4	0.11	-0.12	0.05	0.17	0.07	0.09
EROSFIN					1	0.31	0.46	0.47	0.42	0.39	-0.02	0.63	-0.01	0.44	0.34	0.35	0.31
FILTMAP						1	0.53	0.18	0.32	-0.08	-0.07	0.4	0.04	0.43	0.48	0.04	0.13
GWATUNW							1	0.48	0.44	-0.11	0.07	0.52	0.18	0.54	0.51	0.2	0.33
GWVIPPT								1	0.11	0.37	-0.01	0.5	0.37	0.11	0.06	0.47	0.45
HIDEX									1	0.2	-0.16	0.52	0.05	0.44	0.63	-0.11	0.23
PESTDEX										1	-0.05	0.21	0.12	-0.11	-0.08	-0.03	0.06
SPECIES											1	-0.05	-0.06	-0.09	-0.06	0.27	0.07
WINDUNW												1	0.11	0.36	0.46	0.18	0.4
NRUNUNW													1	-0.05	-0.03	-0.02	0.08
TOTMANUR														1	0.68	0.11	0.17
CROPS															1	-0.06	0.19
FRUIT																1	0.41
VEGS																	1

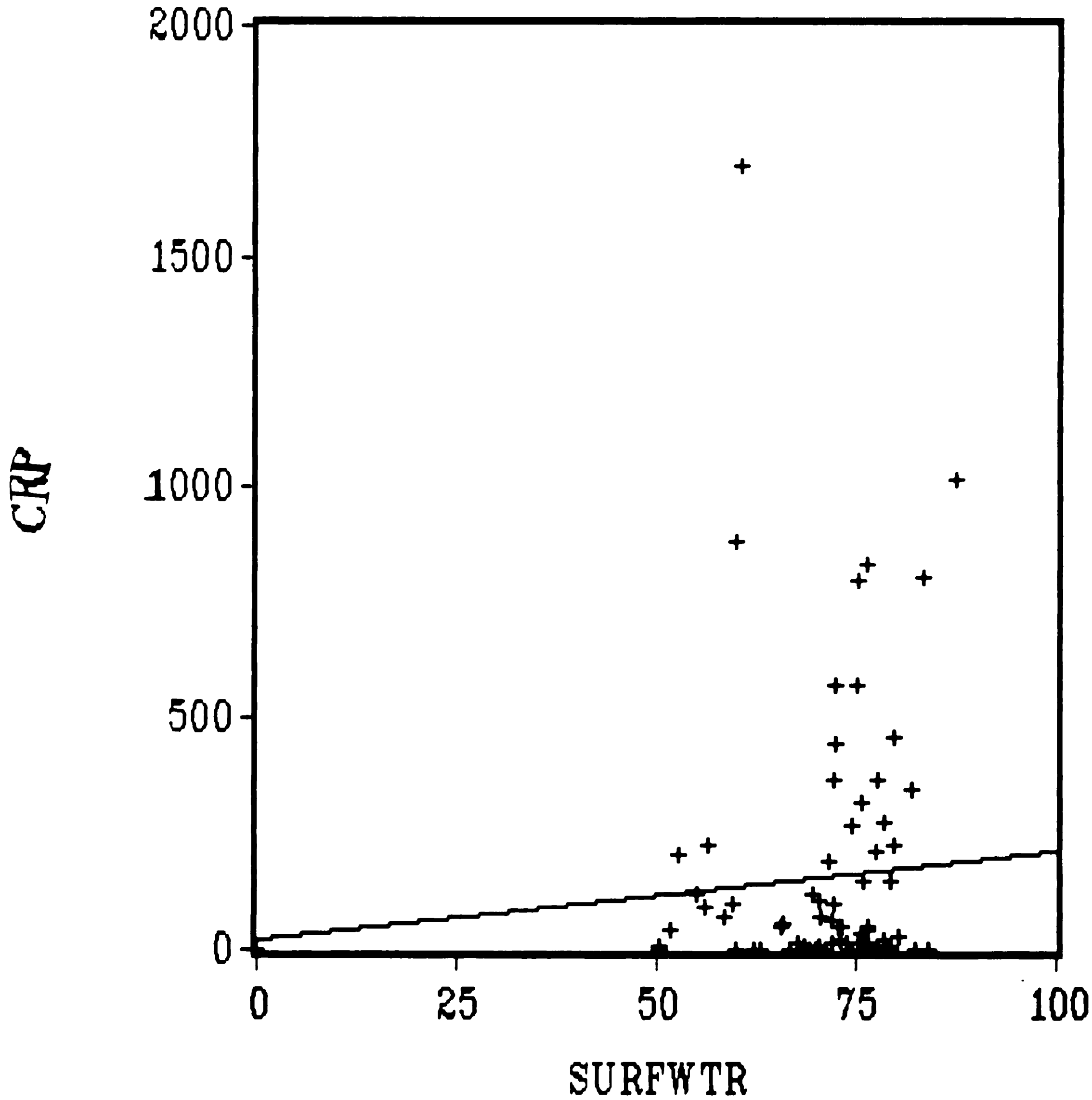
E.11

Scatter Plot of CRP Payments and all Environmental Variables



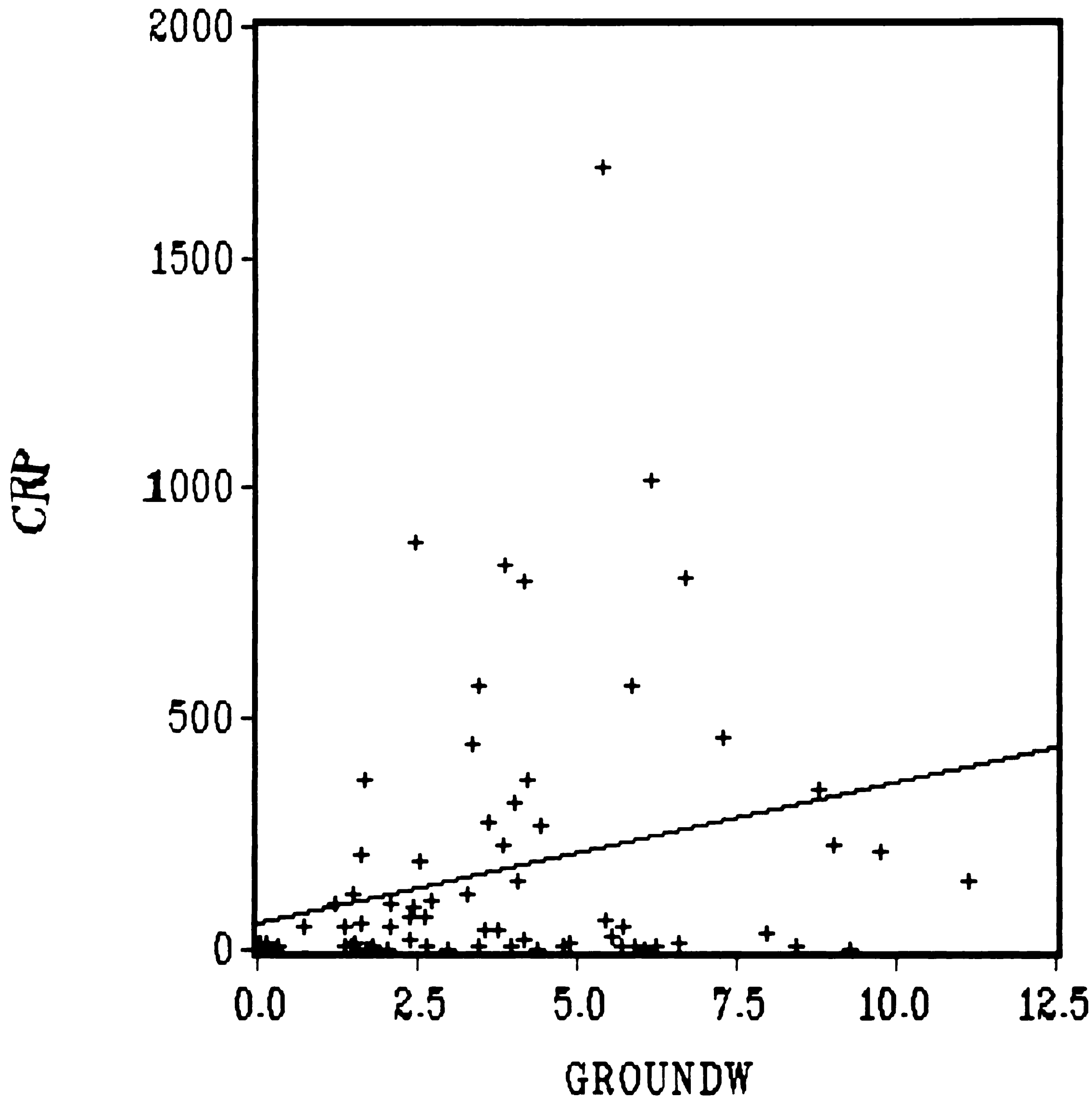
E.12

Scatter Plot of CRP Payments and Potential Surface Water Problems



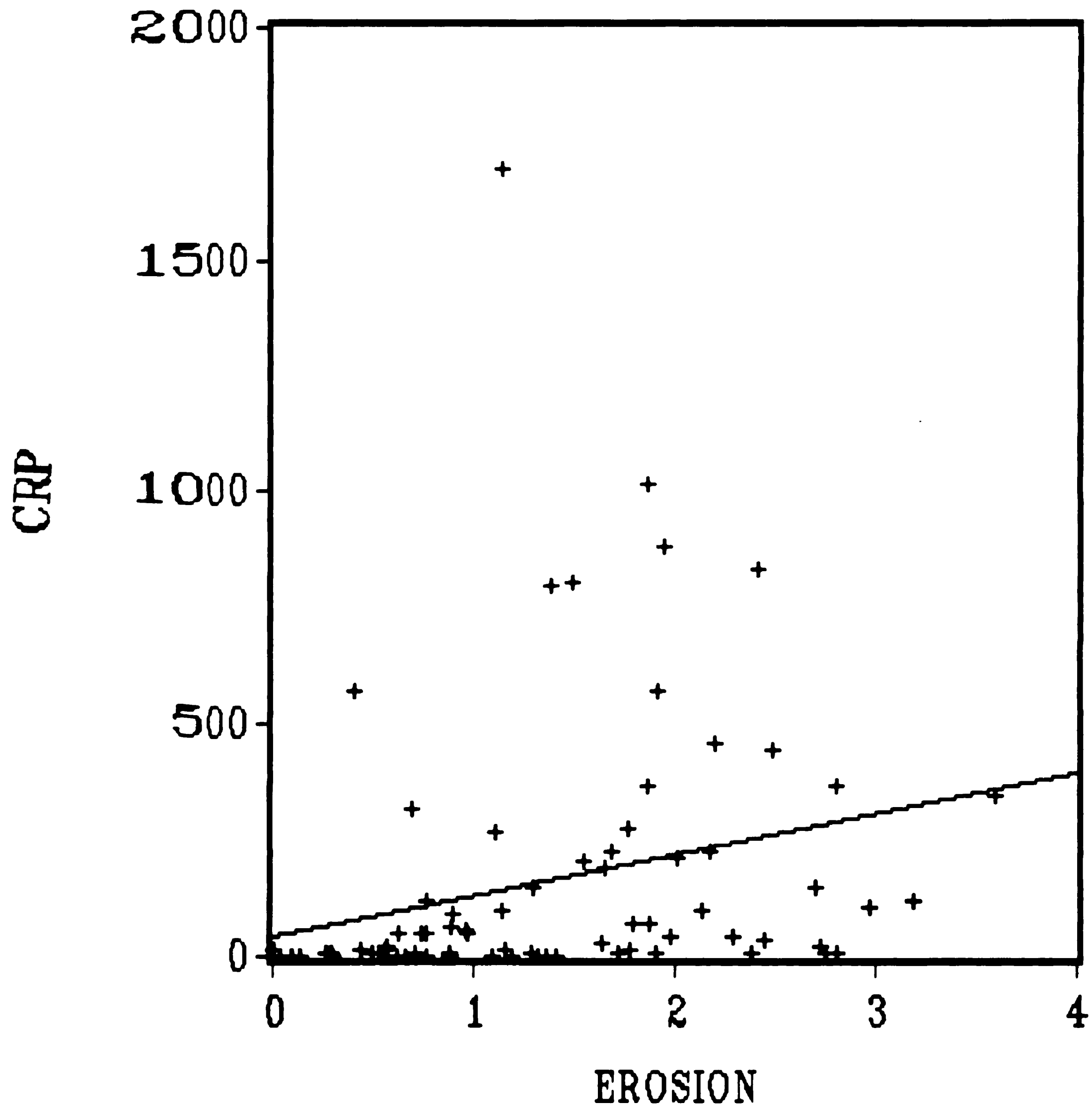
E.13

Scatter Plot of CRP Payments and Potential Groundwater Problems



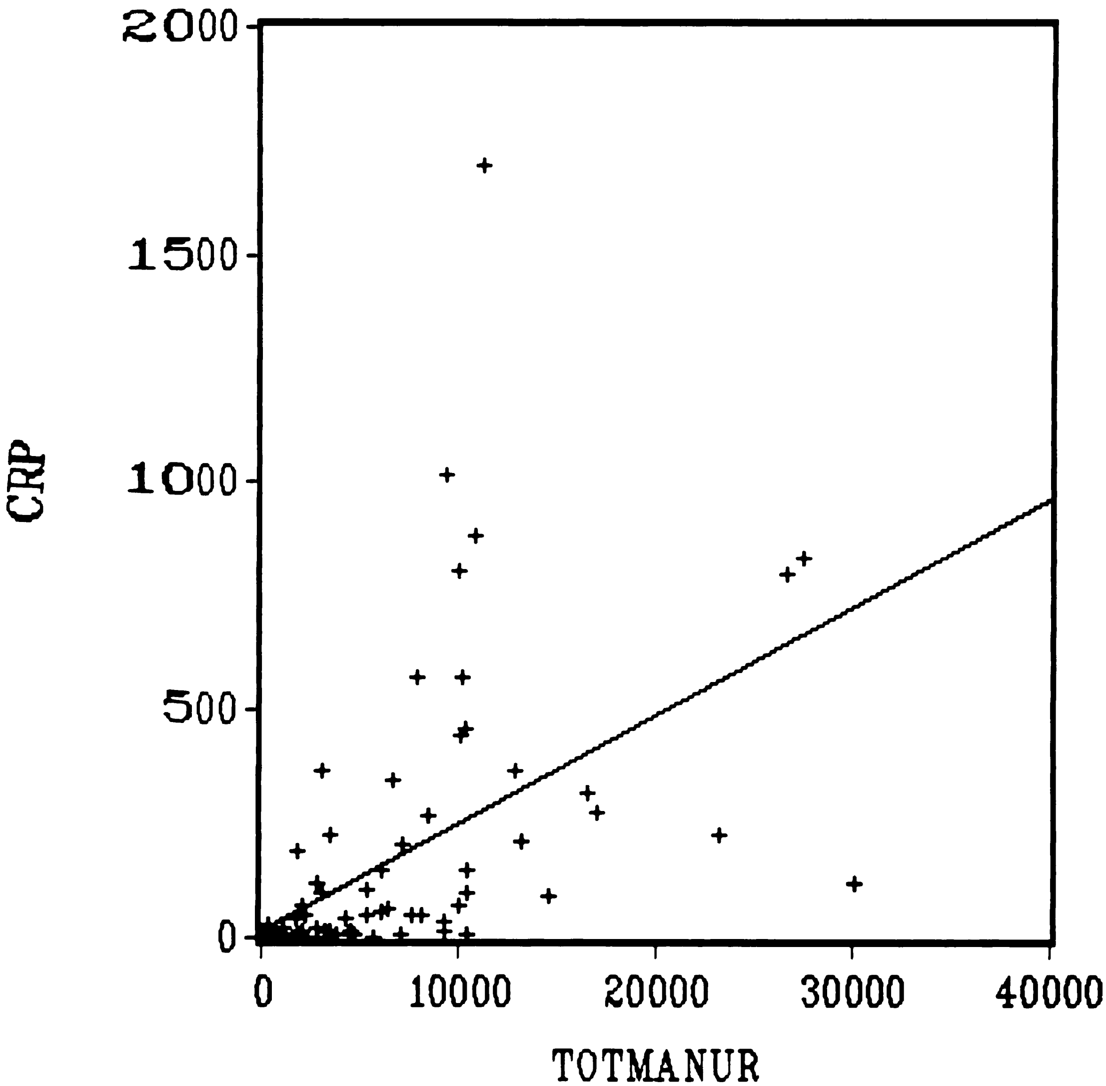
E.14

Scatter Plot of CRP Payments and Potential Erosion Problems



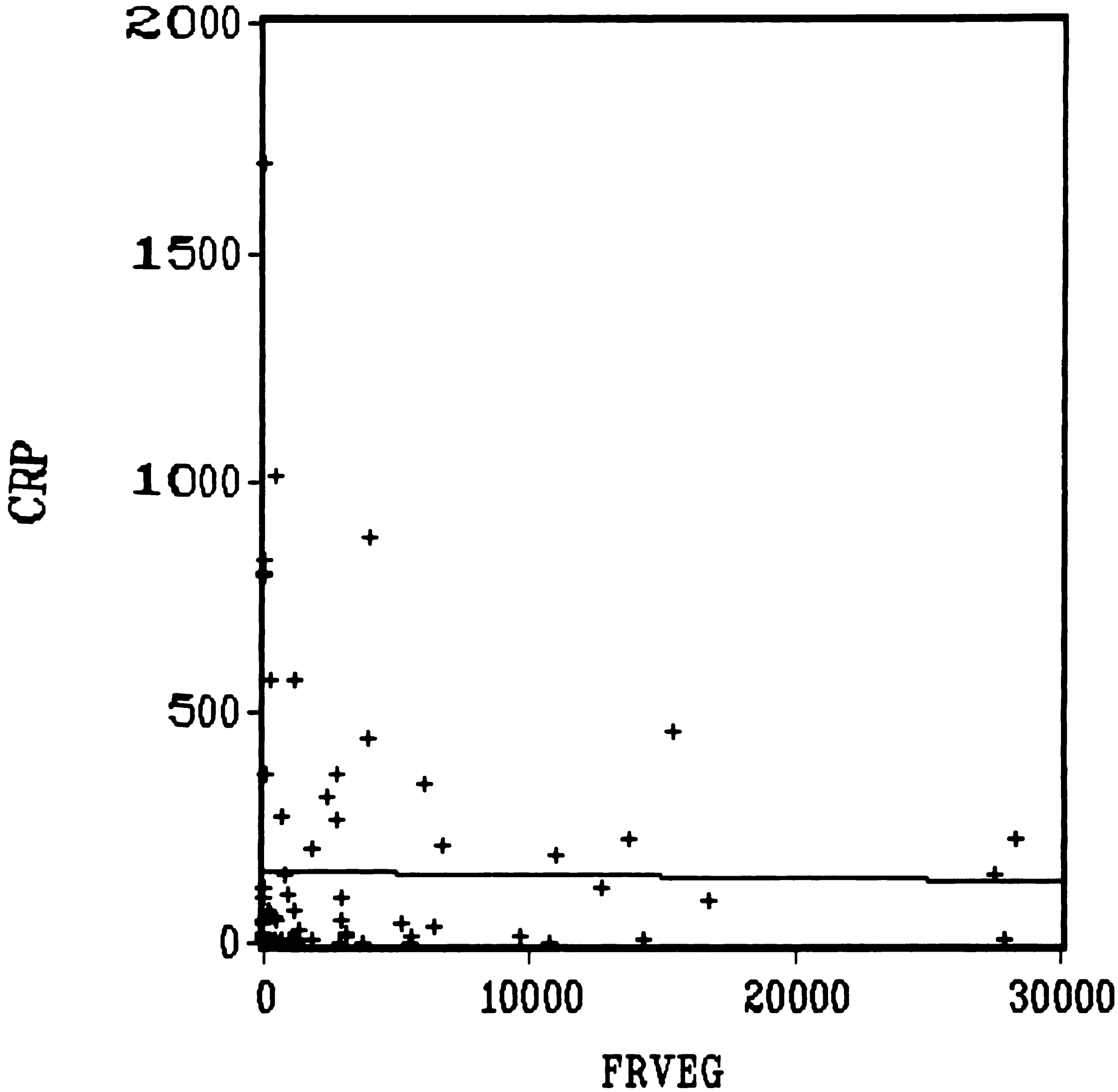
E.15

Scatter Plot of CRP Payments and Total Manure Production



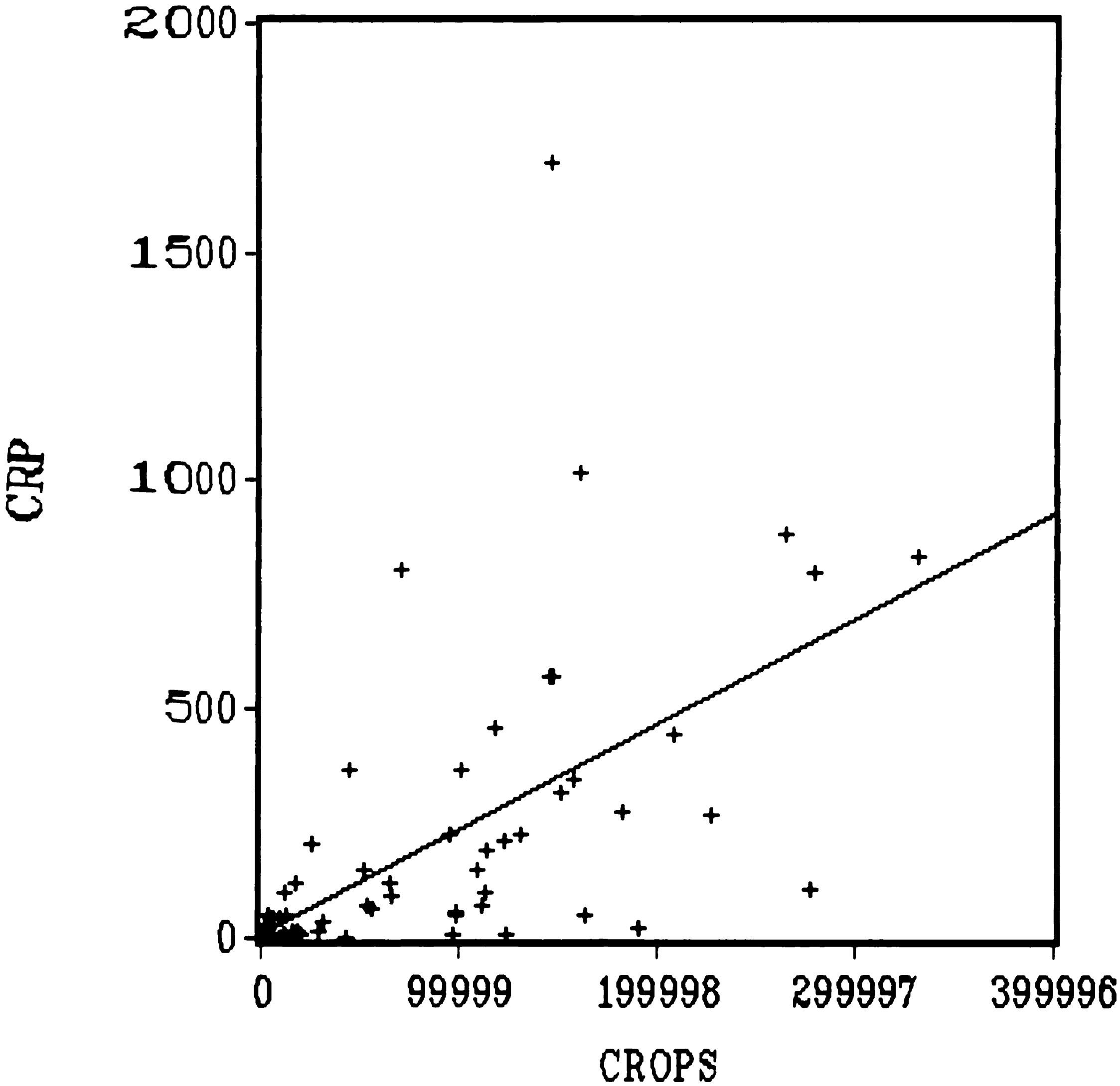
E.16

Scatter Plot of CRP Payments and Fruit and Vegetable Production



E.17

Scatter Plot of CRP Payments and Crop Production



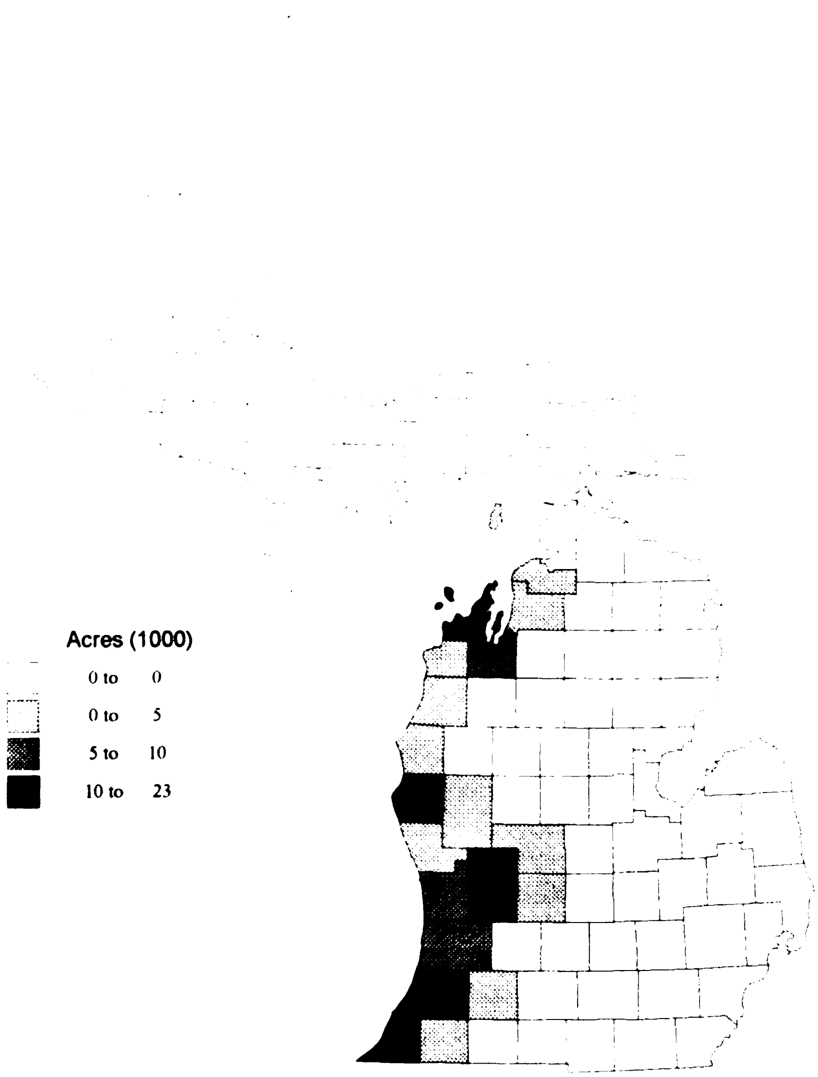
Appendix F

Maps of Agricultural Production

F.1

Planted Fruit Acres

1991

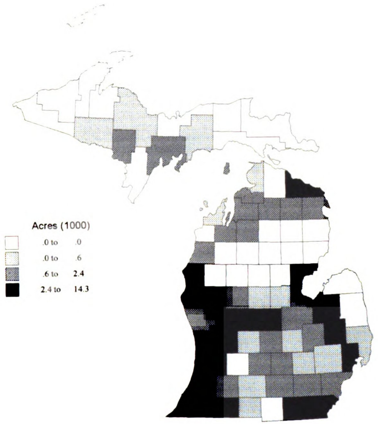


Michigan Rotational Survay, 1992
Ranges based on Fitted Numbers

F.2

Planted Vegetable Acres

1991

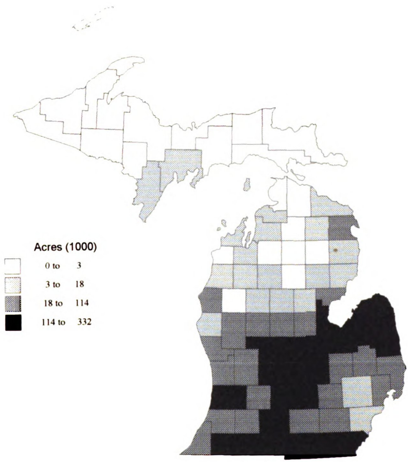


Michigan Rotational Survey, 1992
Ranges based on Quantiles

F.3

Planted Crop Acres

1992



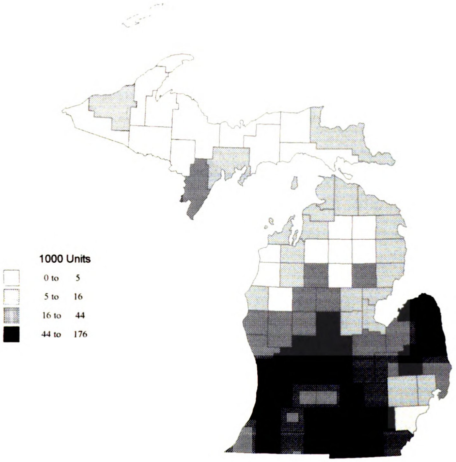
Census of Agriculture, 1993

Ranges based on Quantiles

F.4

Animal Units

1992

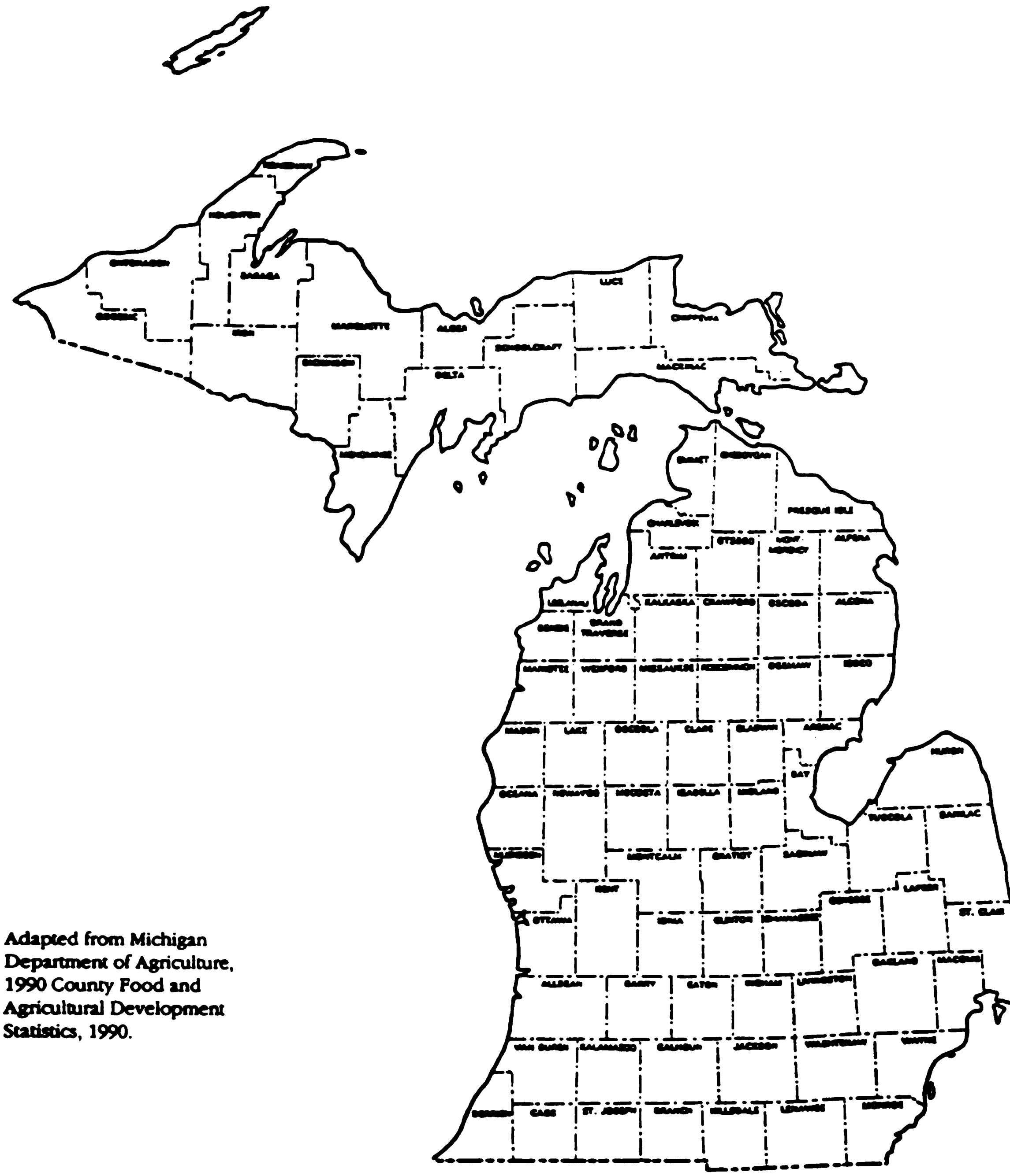


Michigan Agricultural Statistics, 1993
Animal Unit Conversions based on Federal Code of Regulations
Animal Units include Beef, Dairy Cows and Calves (as one conversion), Swine, Sheep and Lambs, Turkeys, Hens

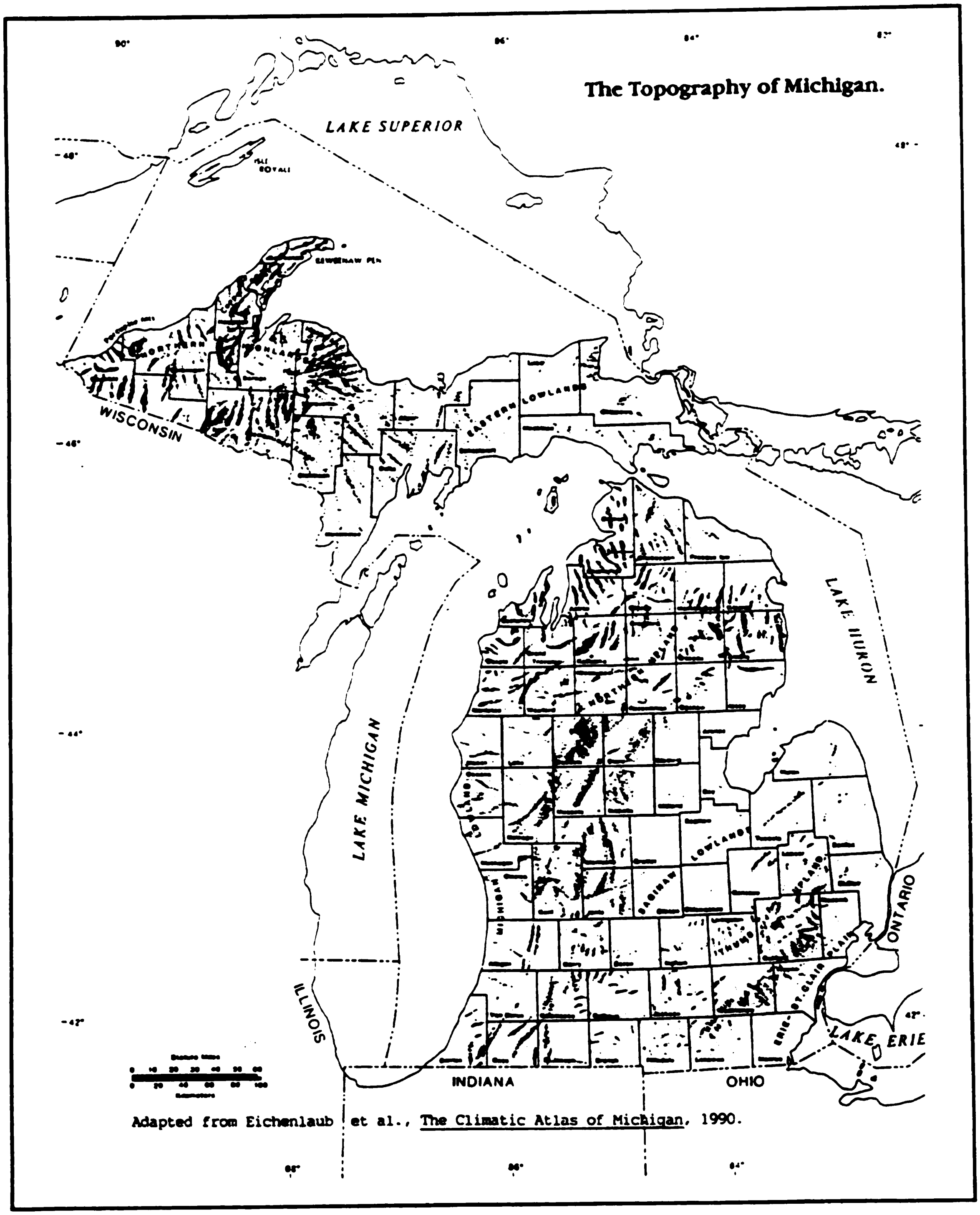
Appendix G

Maps of Michigan's Landscape

The Locations of Michigan's 83 Counties.

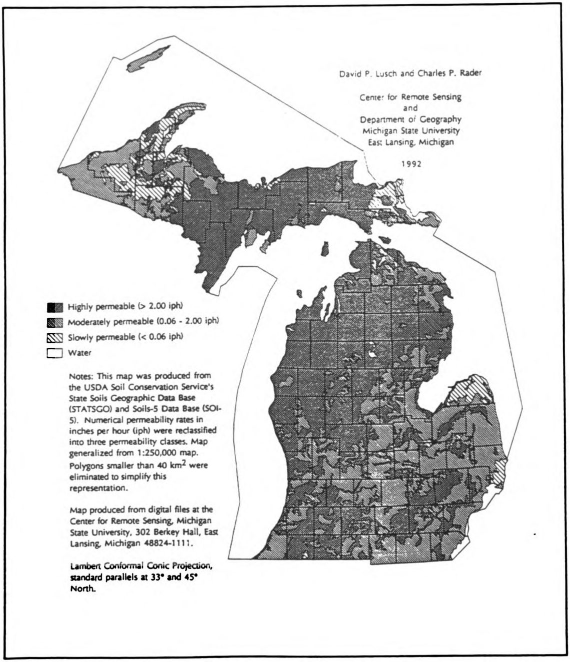


Adapted from Michigan Department of Agriculture, 1990 County Food and Agricultural Development Statistics, 1990.

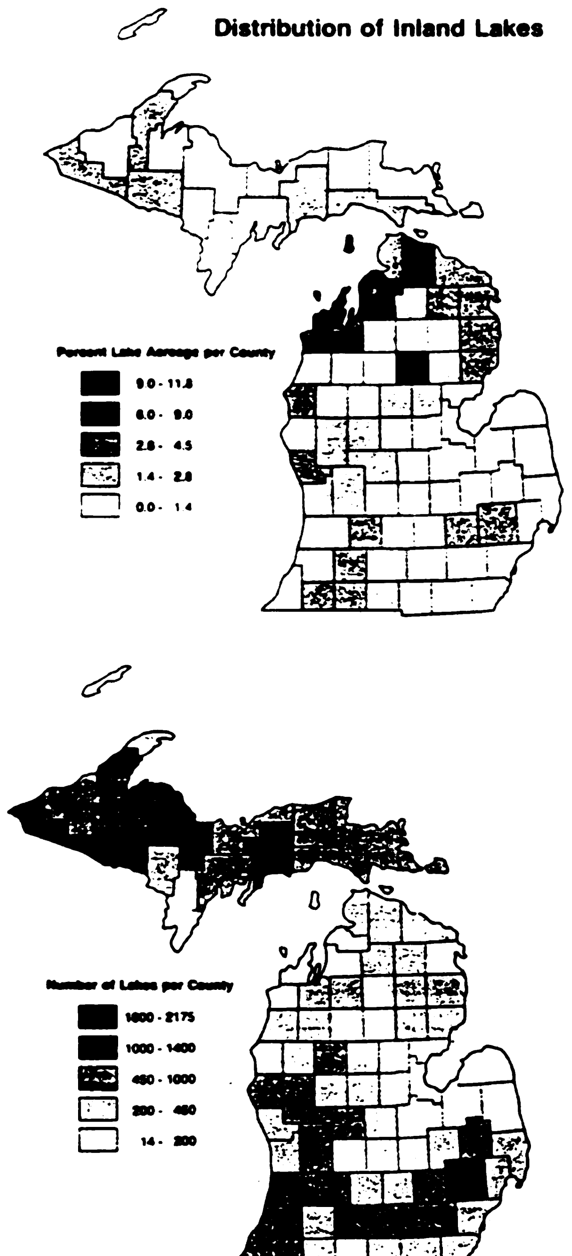


The Topography of Michigan.
LAKE SUPERIOR
WISCONSIN
LAKE MICHIGAN
LAKE HURON
ILLINOIS
INDIANA
OHIO
ONTARIO
LAKE ERIE
Adapted from Eichenlaub et al., The Climatic Atlas of Michigan, 1990.

Soil Permeability in Michigan.

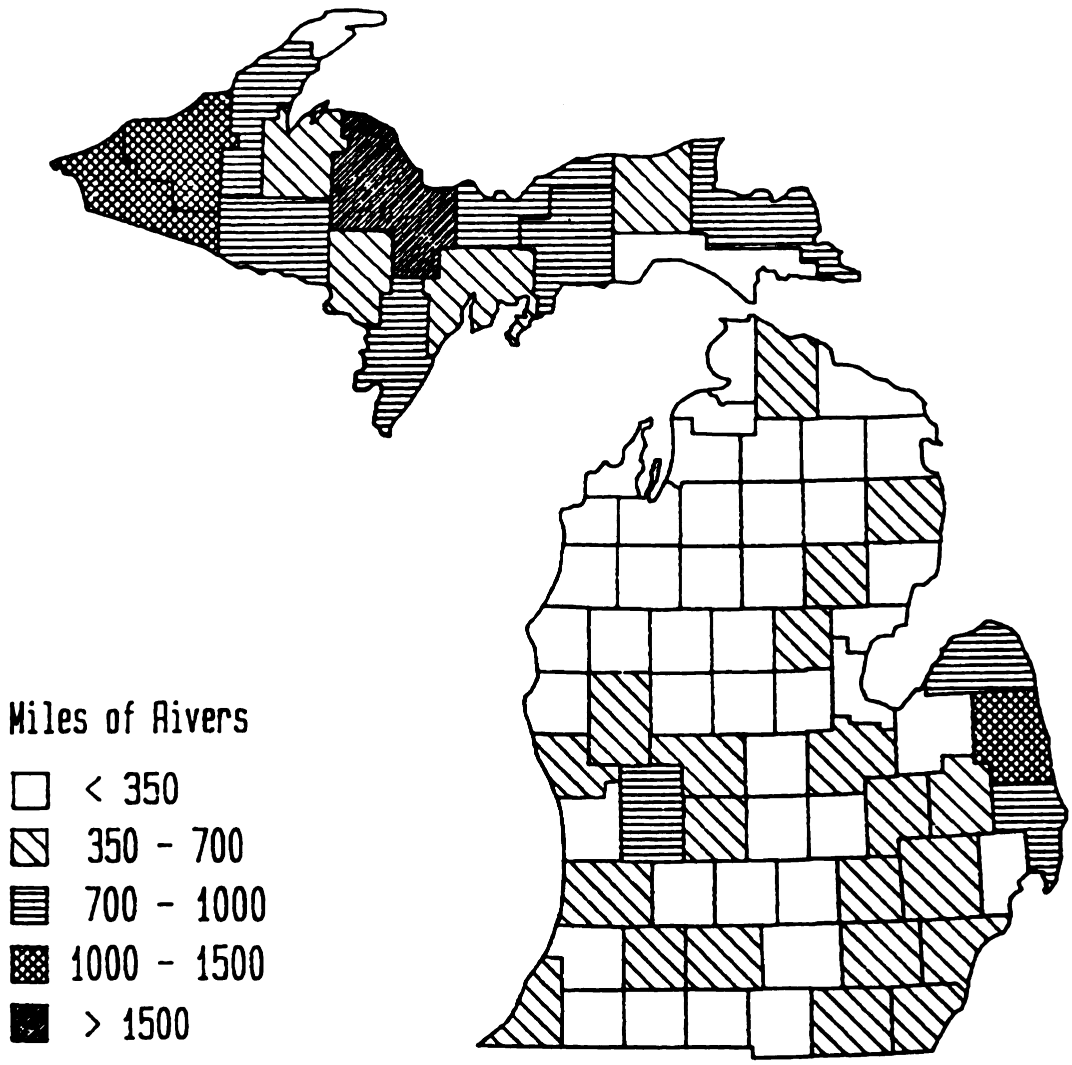


Distribution of Inland Lakes in Michigan



Adapted from the Institute of Water Research, Michigan State University, *An Introduction to Michigan's Water Resources*, 1991.

The Distribution of Rivers in Michigan by County.

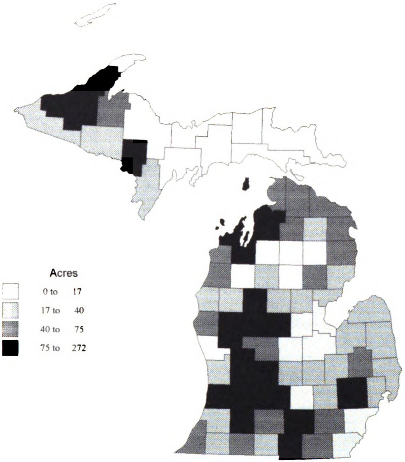


Center for Remote Sensing, Michigan State University, 1991.
Data obtained from Brown, 1985.

G.5

Acres of Cropland

Slopes 2 to 12 % With a Stream Present



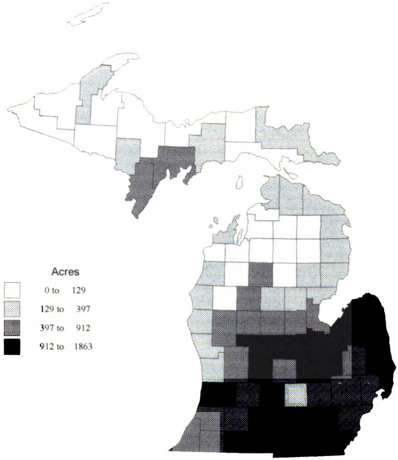
L&L and Associates, W. Lafayette, IN, 1994

Calculation of Acres based on Quantiles

G.5.1

Acres of Cropland

Slope 0 to 2 %, Stream Present

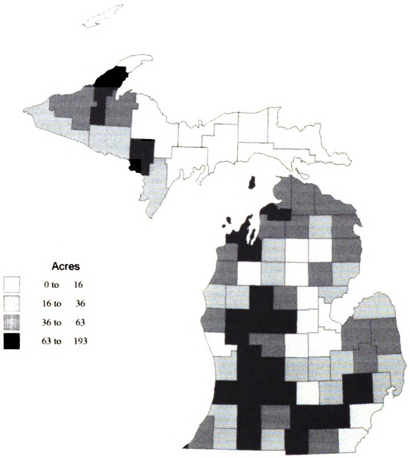


L&L and Associates, W. Lafayette, IN, 1994
Ranges based on Quantiles

G.5.2

Acres of Cropland

Slope 2 to 4 %, Stream Present



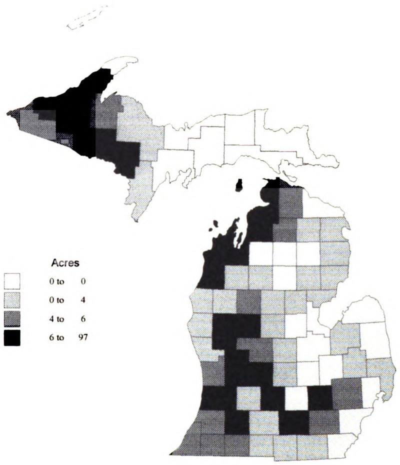
L&L and Associates, W. Lafayette, IN, 1994

Ranges based on Quantiles

G.5.3

Acres of Cropland

Slope 4 to 6 %, Stream Present

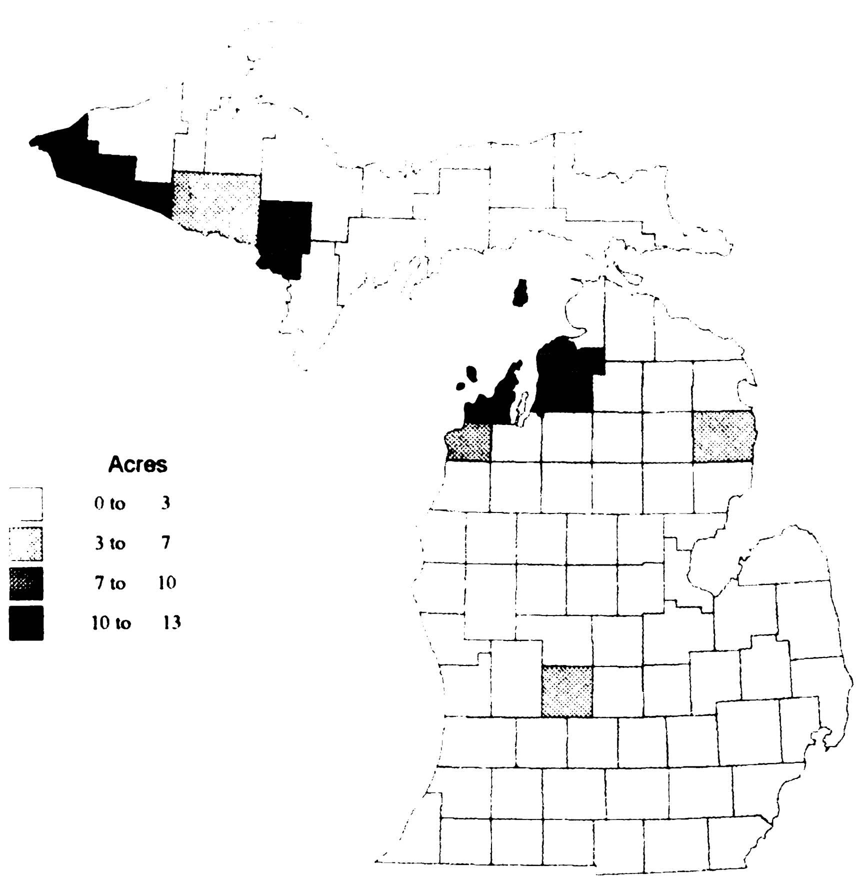


L&L and Associates, W. Lafayette, IN, 1994
Ranges based on Quantiles

G.5.4

Acres of Cropland

Slope 6 to 9 %, Stream Present

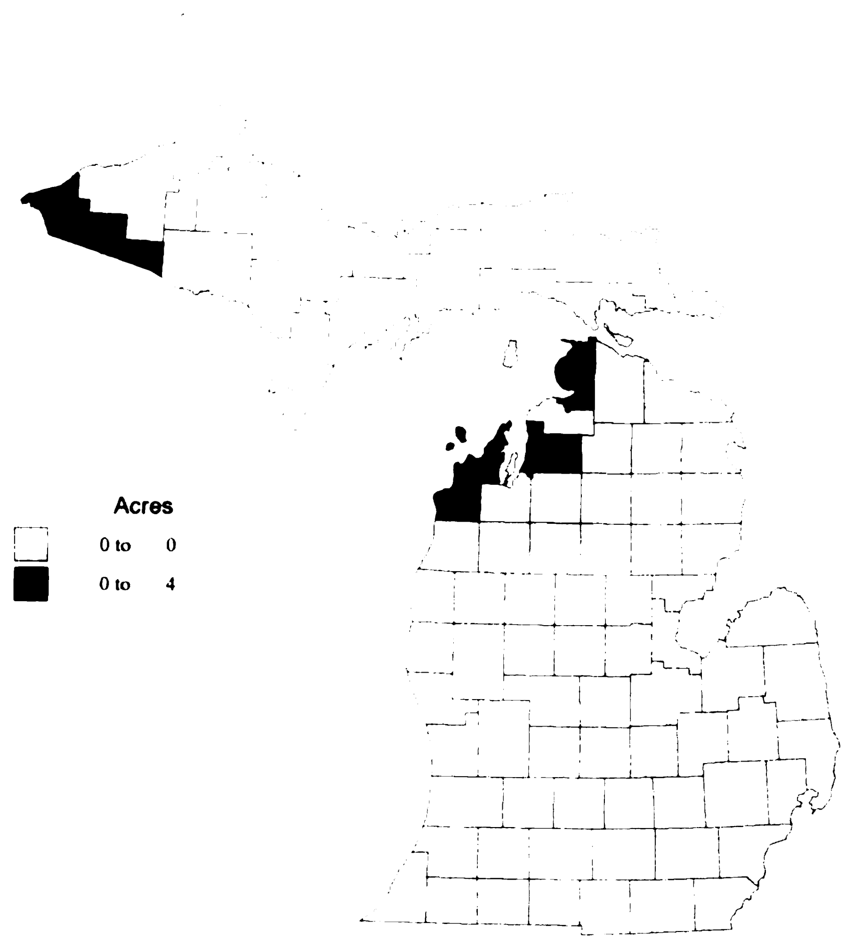


L&L and Associates, W. Lafayette, IN, 1994
Ranges based on Equal Size

G.5.5

Acres of Cropland

slope 9 to 12 %, stream present

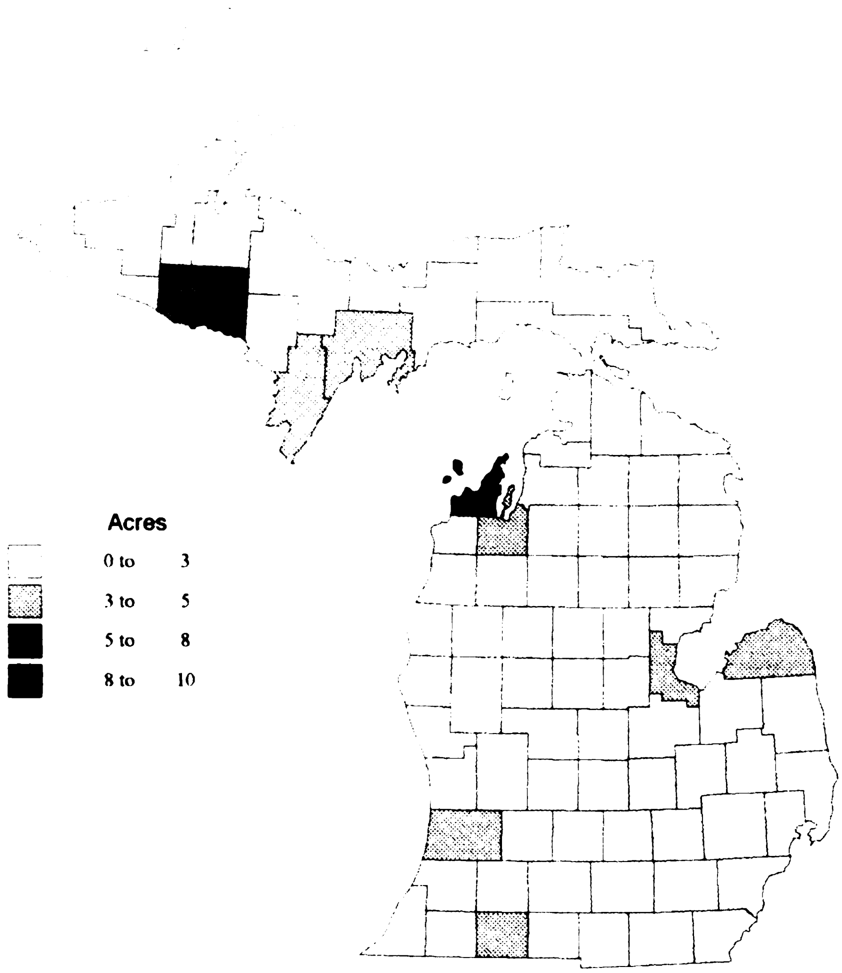


L&L and Associates, W. Lafayette, IN, 1994

G.5.6

Acres of Cropland

Slope Greater Than 12 %, Stream Present



L&L and Associates, W. Lafayette, IN, 1994

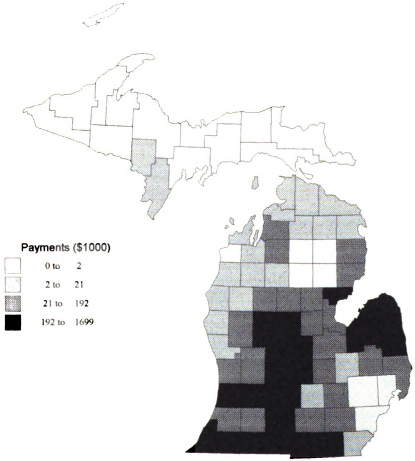
Ranges based on Equal Size

Appendix H

Maps of Federal Program Payments

H.1
Conservation Reserve Program Payments

1991

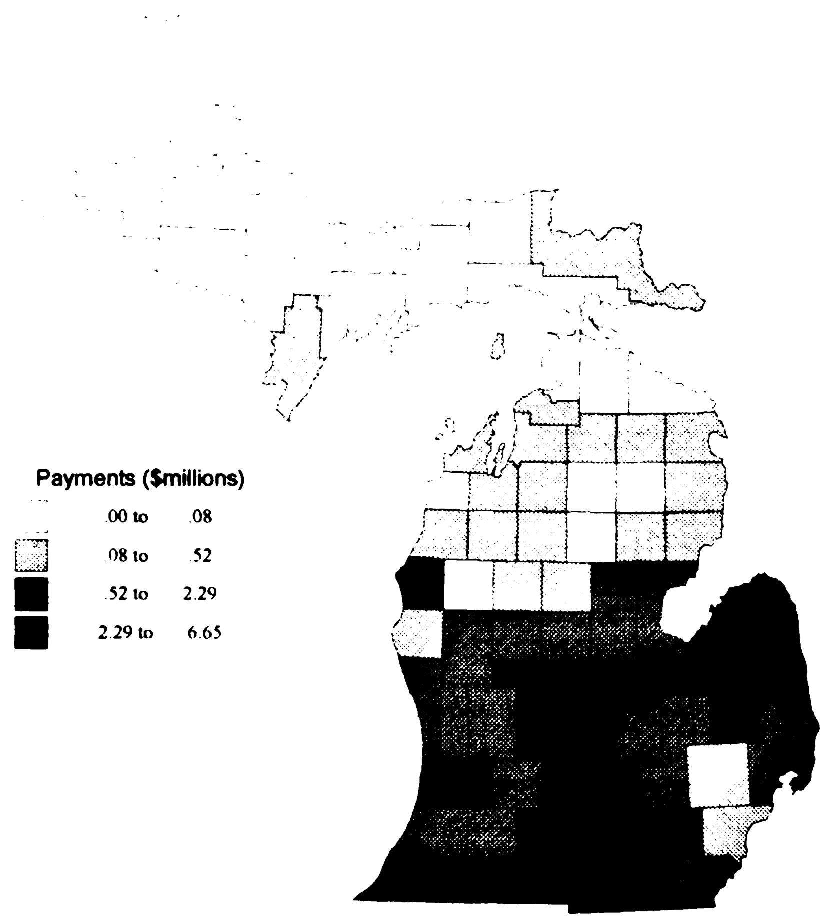


Economic Research Service, United Steas Department of Agriculture, Washington, DC
Ranges based on Quantiles

H.2

Commodity Program Payments

1991



Economoc Research Service, United States Department of Agriculture, Washington, DC, 1991

Ranges based on Quantiles

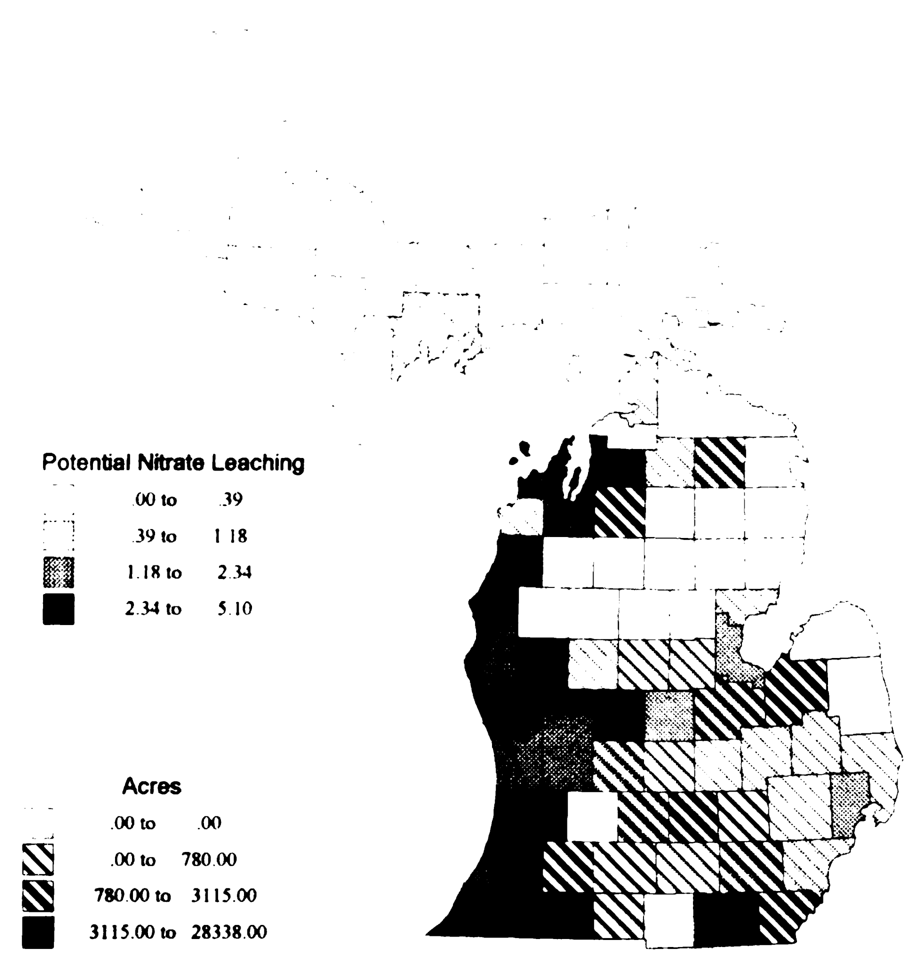
Appendix I

Maps of Agricultural Production and Potential Environmental Problems

I.1

Potential Nitrate Leaching and

Fruit and Vegetable Production

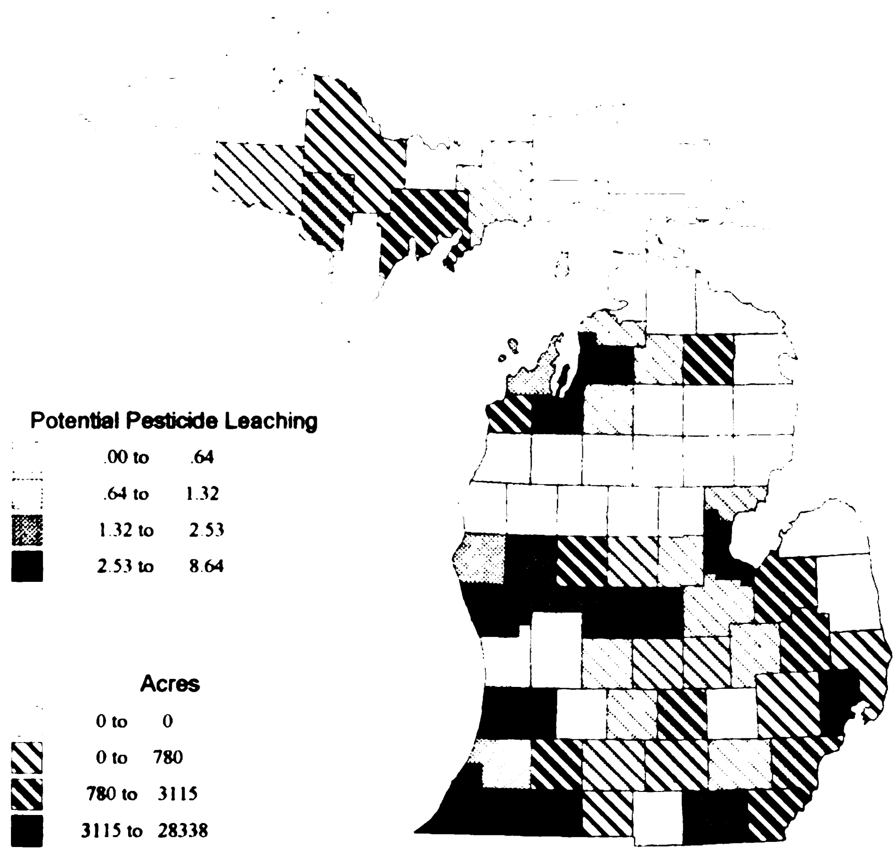


Environmental Working Group, Washington, DC
Michigan Rotational Survey, 1992
Ranges based on Quantiles

I.2

Potential Pesticide Leaching and

Fruit and Vegetable Production

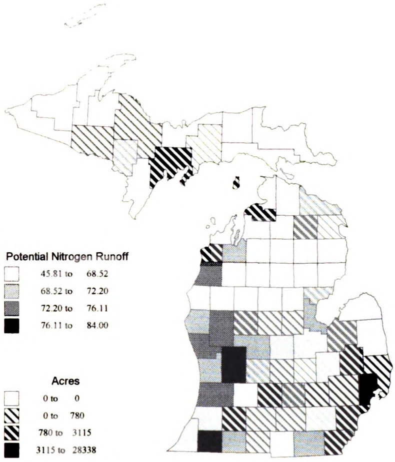


Environmental Working Group, Washington, DC
Michigan Rotational Survey, 1992
Ranges based on Quantiles

I.3

Potential Nitrogen Runoff and

Fruit and Vegetable Production

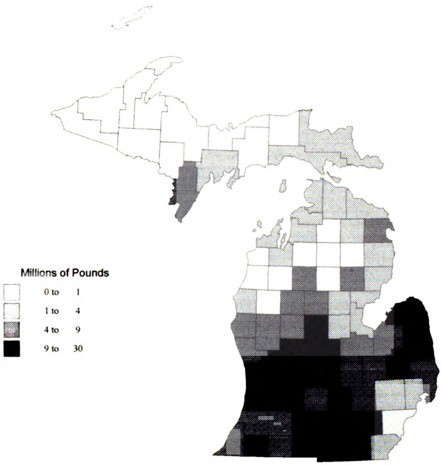


Environmental Working Group, Washington, DC
Michigan Rotational Survey, 1992
Ranges based on Quantiles

I.4

Total Manure

1992



Calculations based on Manure Management Sheets, Record Keeping System for Crop Production, Cooperative Extension Service

Michigan State University, Extension Bulletin E-2344, 1993

Manure calculations include Dairy and Beef Cattle, Swine, Sheep, and Poultry.

Ranges based on Quantiles

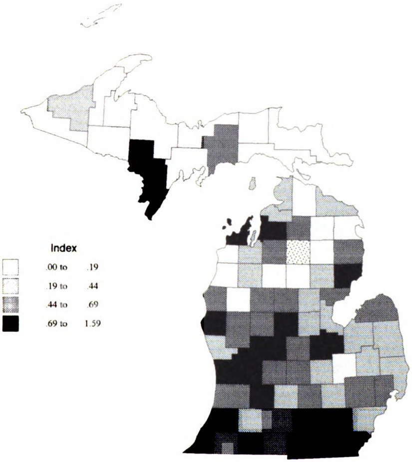
Appendix J

Maps of Environmental Problems Relating to Soil Erosion

J.1

Potential Soil Productivity Loss

no weights applied

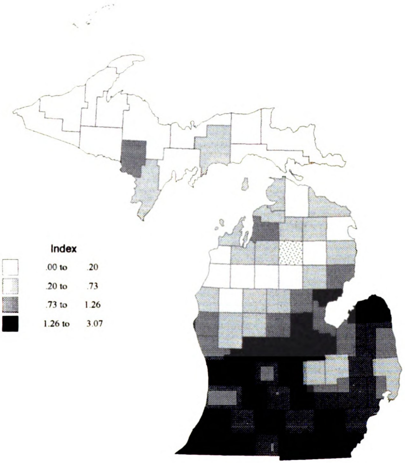


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

J.2

Potential Soil Productivity Loss

weighted by dryland cash rent per year

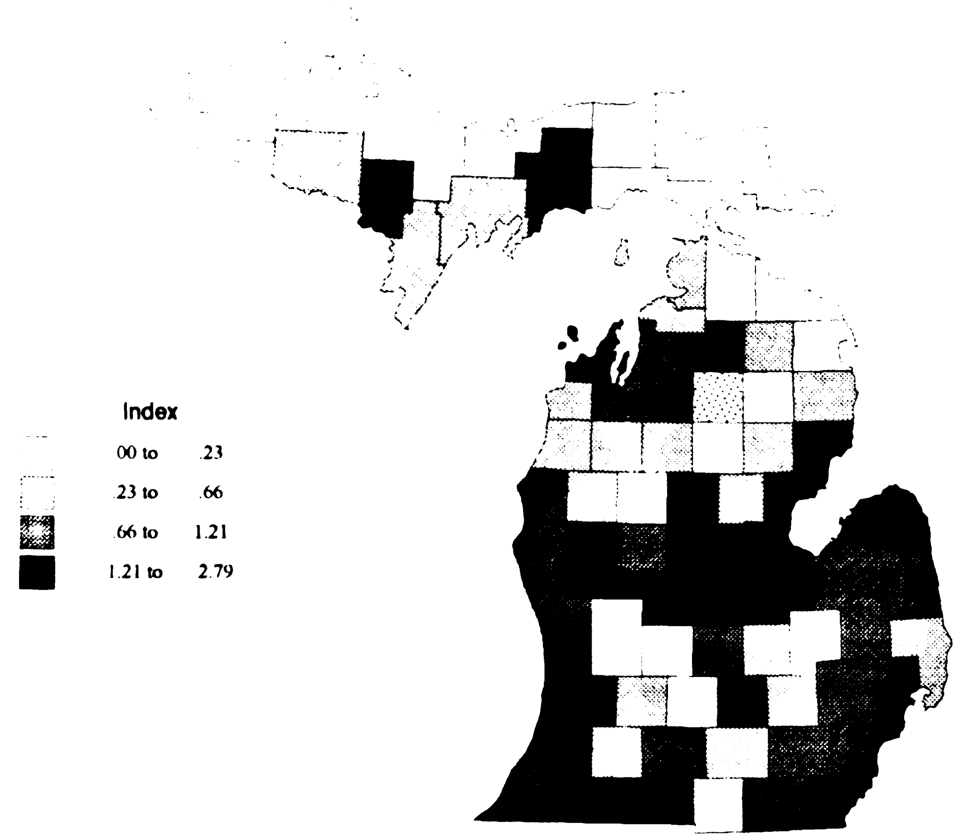


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

J.3

Potential Windblown Dust

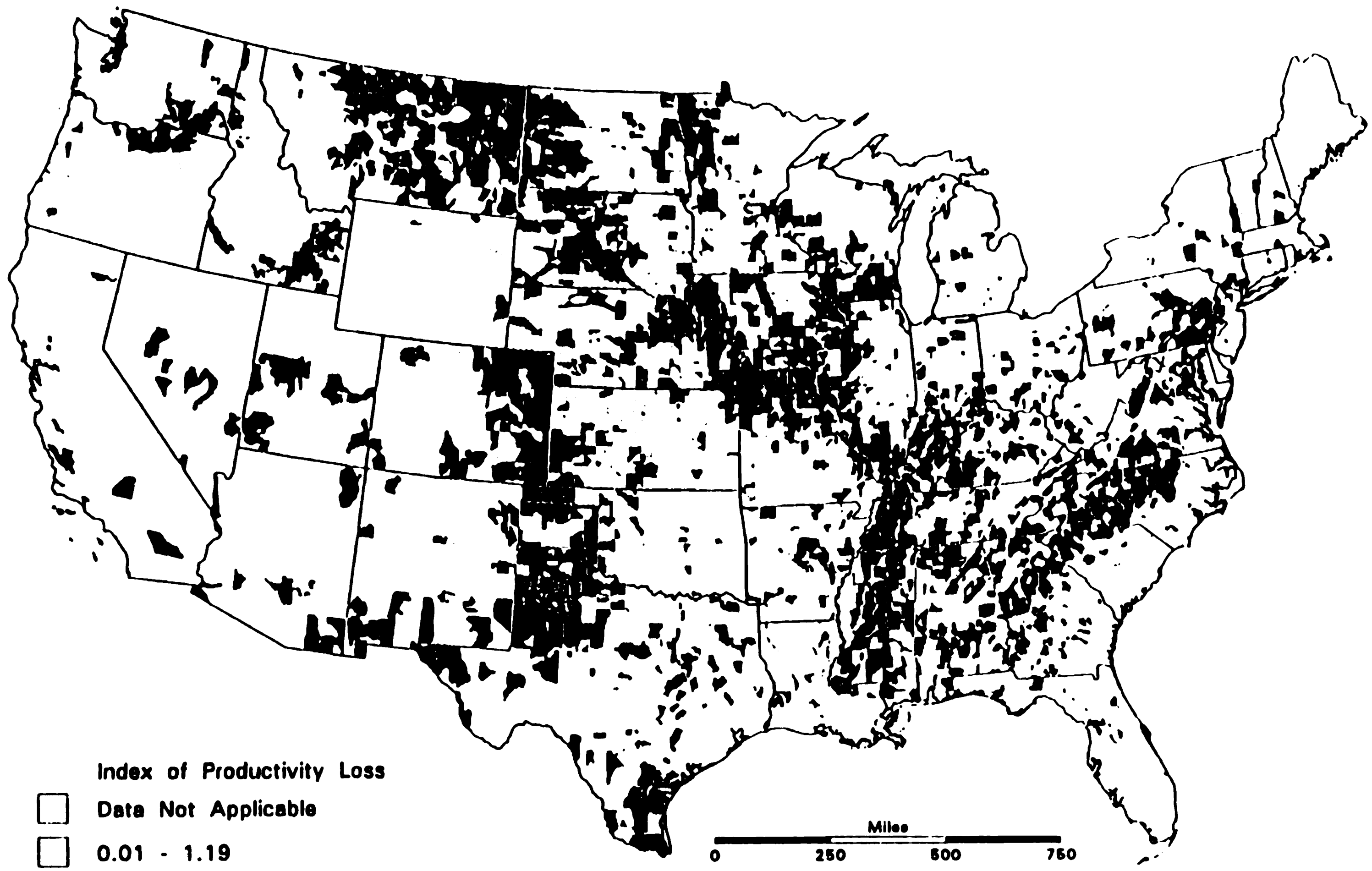
no weights applied



Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

J.4

Potential Soil Productivity Loss
Inverse of years of topsoil depth remaining at current erosion rates



Index of Productivity Loss

- Data Not Applicable
- 0.01 - 1.19
- 1.20 - 2.59
- 2.60 - 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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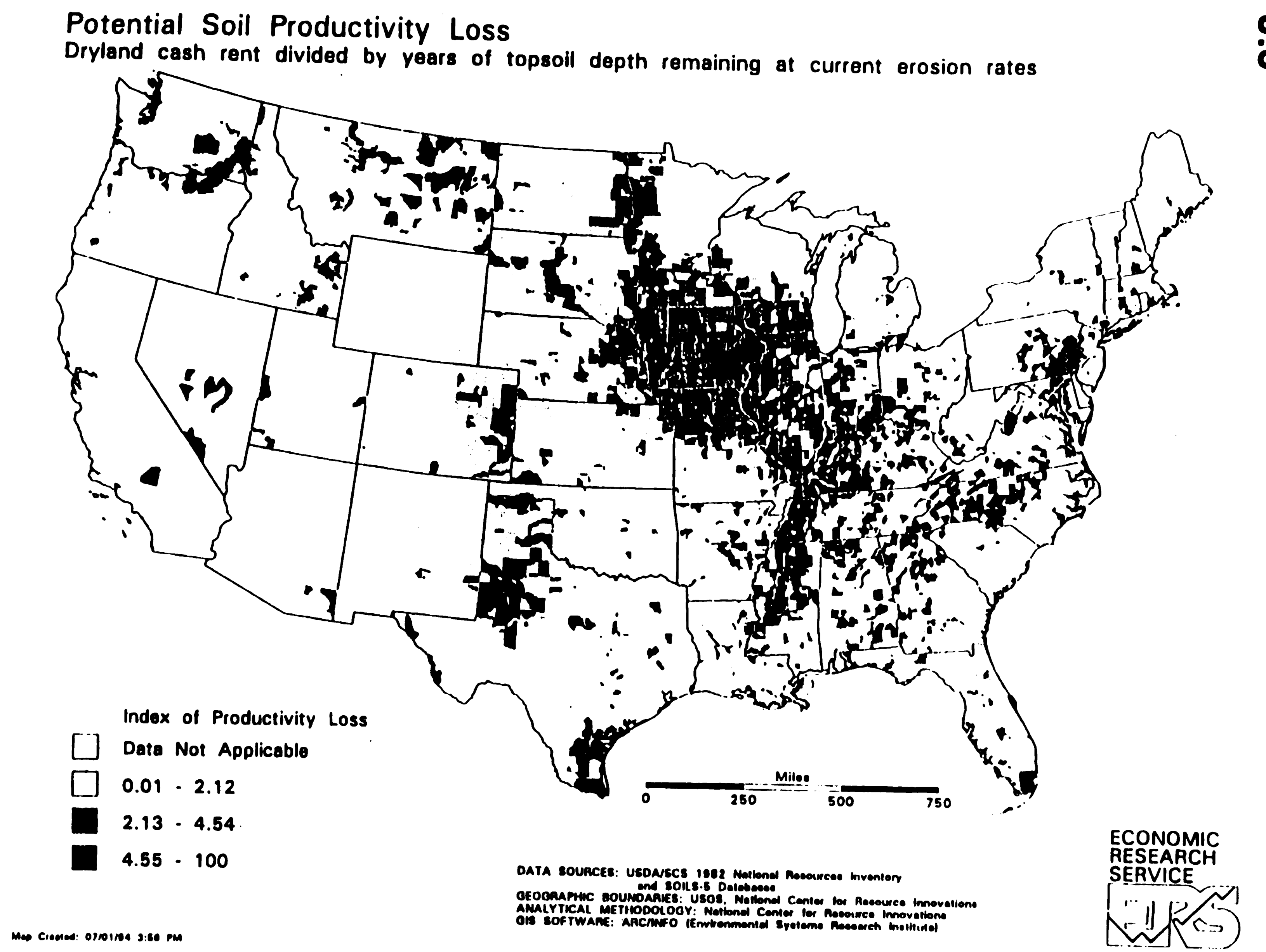
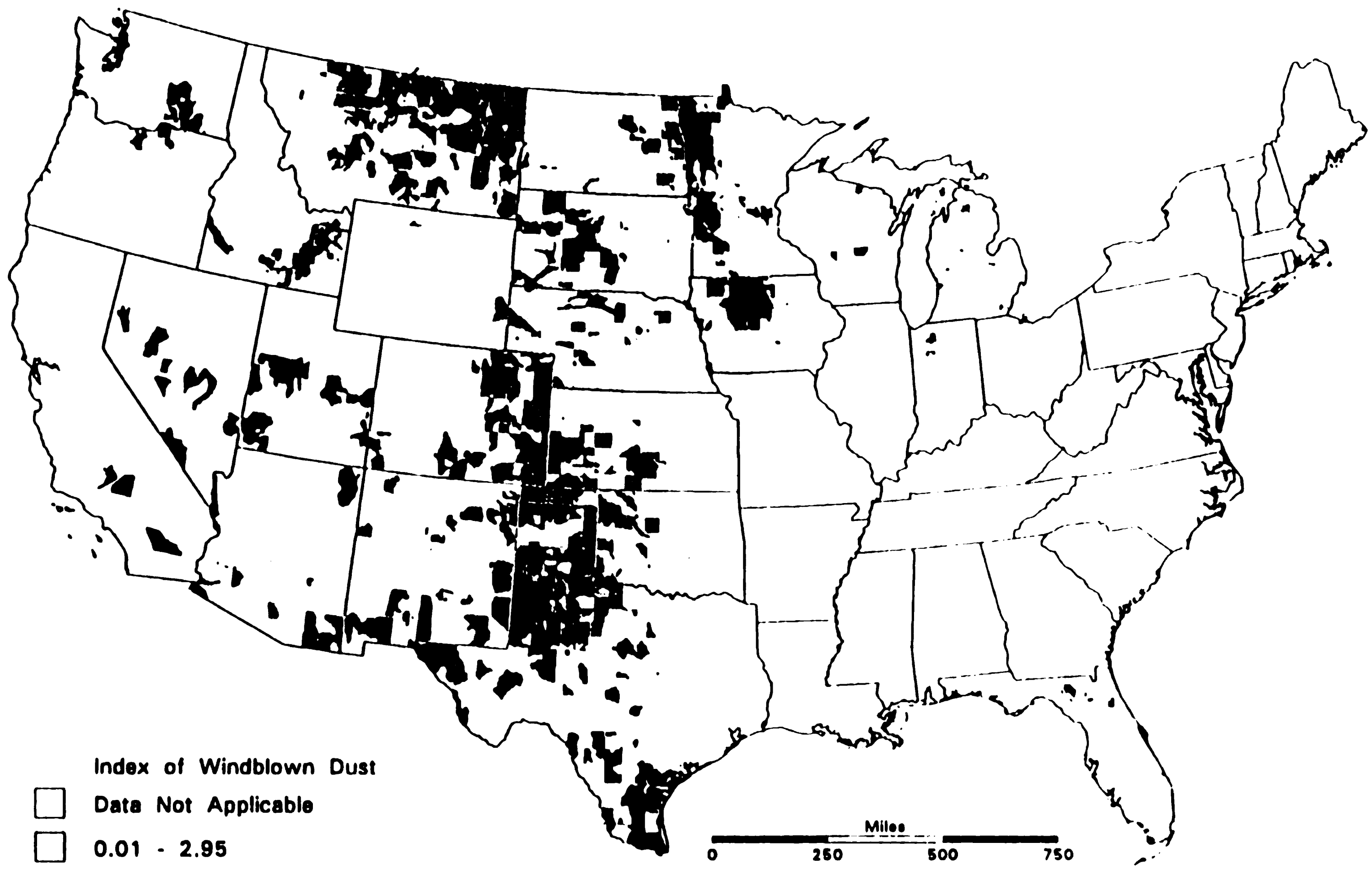
Map Created: 07/01/84 3:53 PM

J.5


Potential Soil Productivity Loss
Dryland cash rent divided by years of topsoil depth remaining at current erosion rates
Index of Productivity Loss
Data Not Applicable
0.01 - 2.12
2.13 - 4.54
4.55 - 100
Miles
0
250
500
750
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)
Map Created: 07/01/94 3:58 PM
ECONOMIC RESEARCH SERVICE

J.6

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 3:08 PM

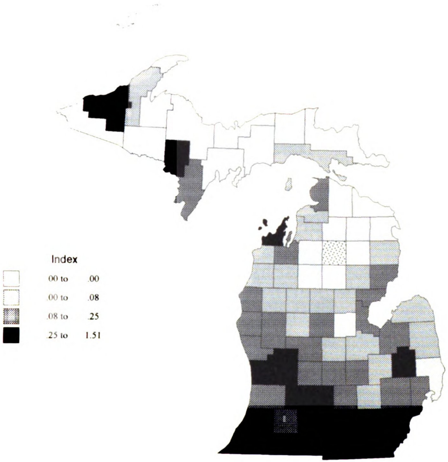
Appendix K

Maps of Environmental Problems Relating to Surface Water

K.1

Potential Sediment Delivery

no weights applied

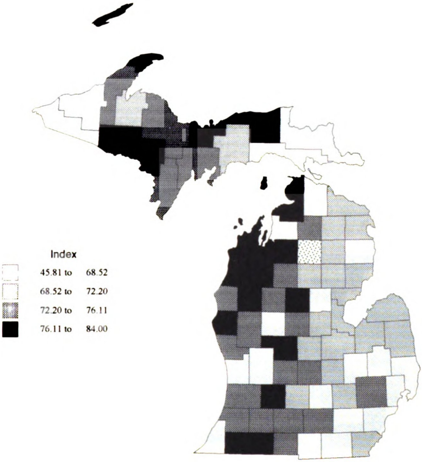


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

K.2

Potential Nitrogen Runoff

no weights applied

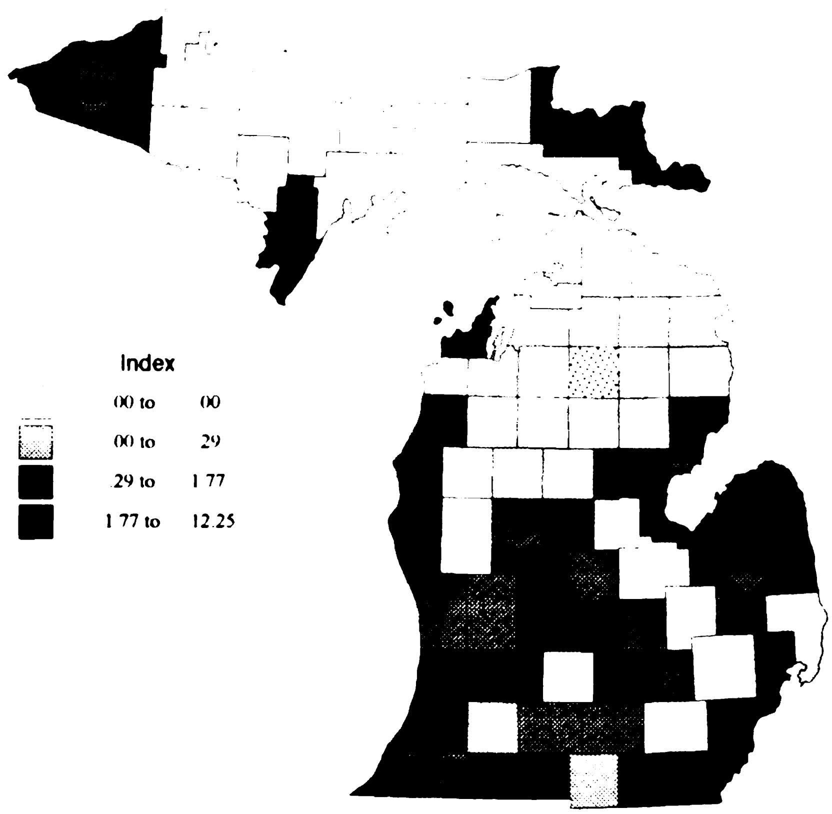


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

K.3

Potential for Filter Strips

no weights applied

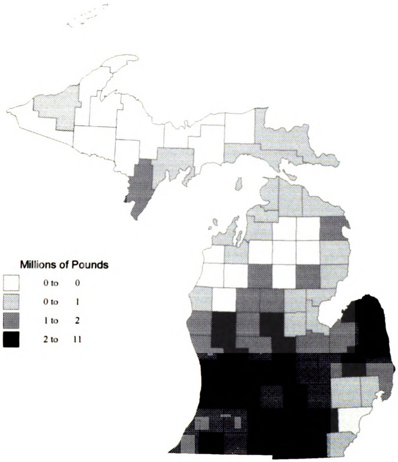


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

K.4

Total Phosphorous Content of Manure

1992

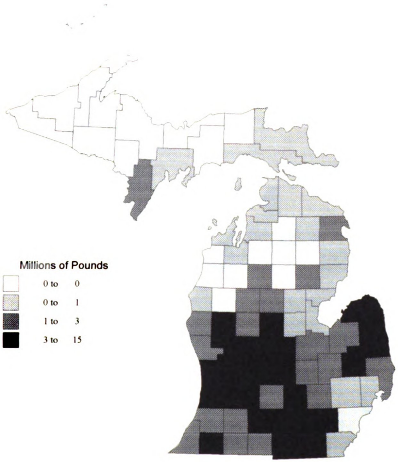


Calculations based on Manure Management Sheets, Record Keeping System for Crop Production, Cooperative Extension Service, Michigan State University, Extension Bulletin E-2344, 1993
Phosphorous calculations include Dairy and Beef Cattle, Swine, Sheep, and Poultry.
Ranges based on Quantiles

K.5

Total Nitrogen Content of Manure

1992



Calculations based on Manure Management Sheets, Record Keeping System for Crop Production, Cooperative Extension Service, Michigan State University, Extension Bulletin E-2344, 1993

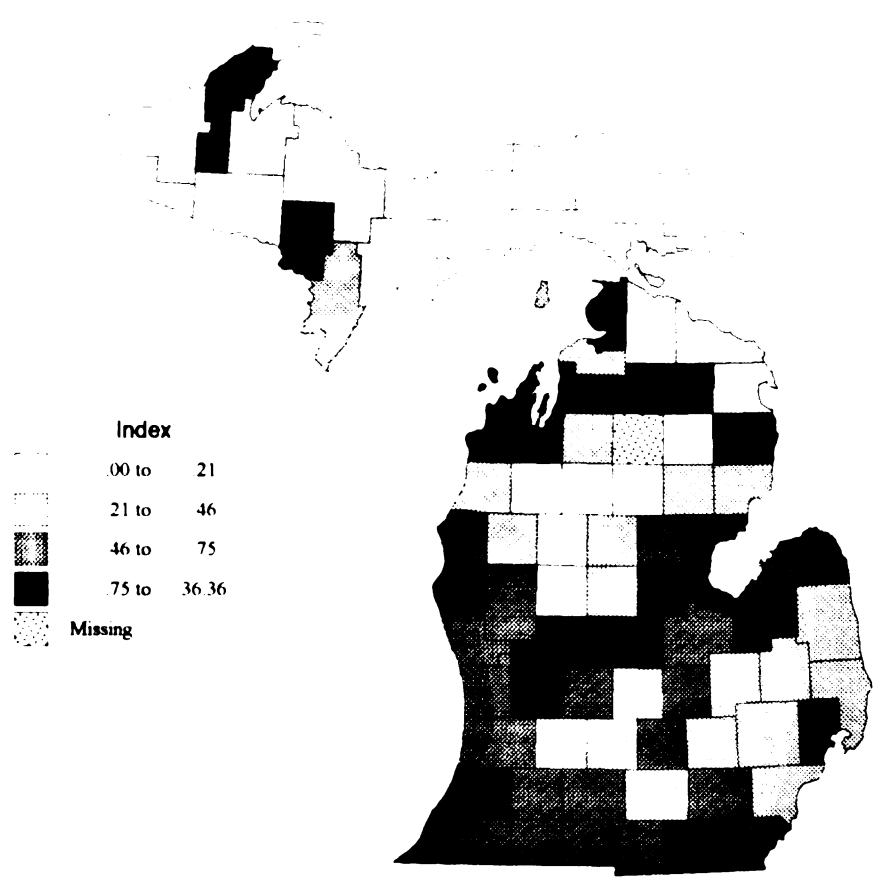
Nitrogen calculations include Dairy and Beef Cattle, Swine, Sheep, and Poultry.

Ranges based on Quantiles

K.6

Potential Pesticide Exposure

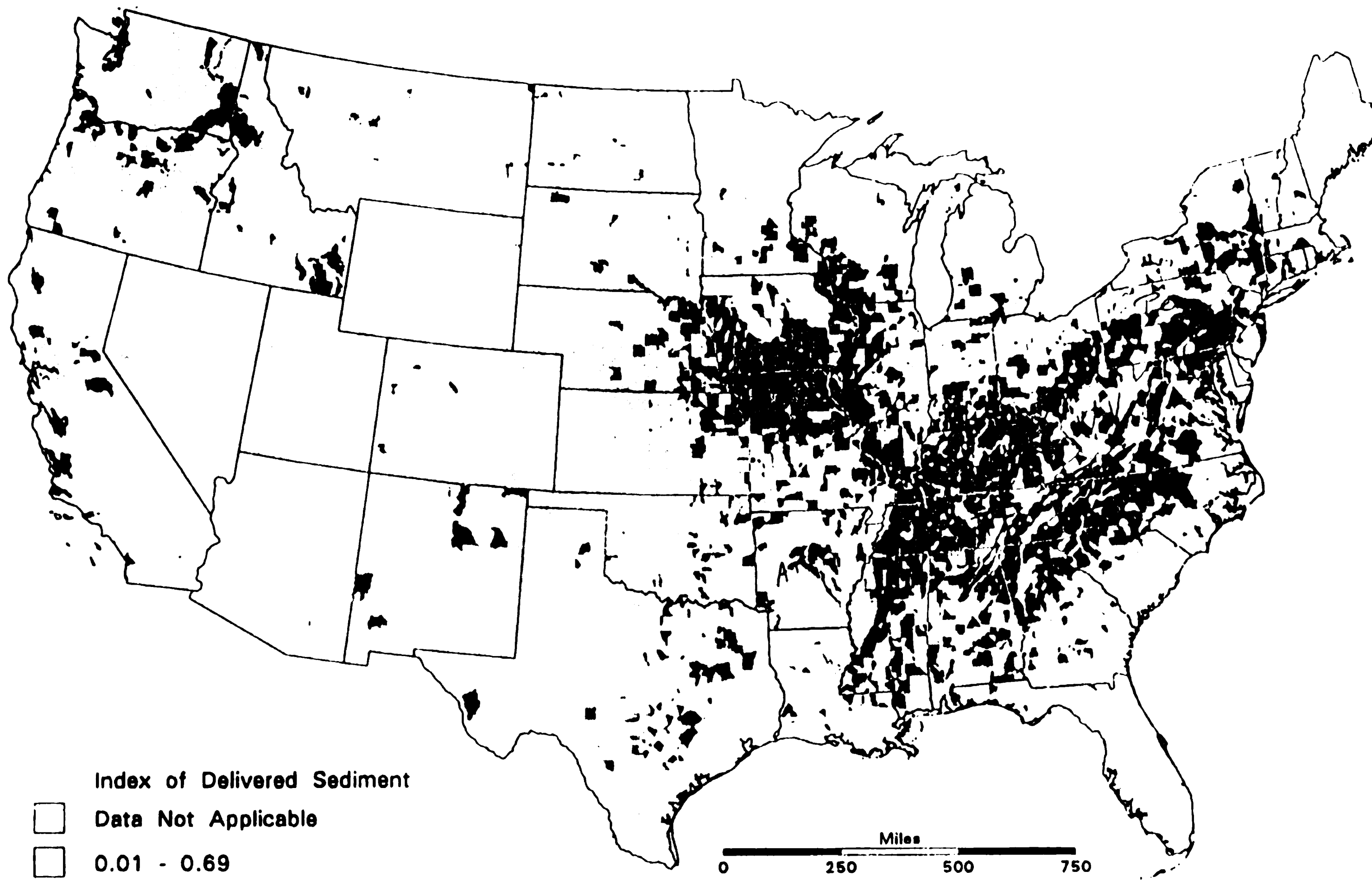
no weights applied



Economic Research Service, Unites States Department of Agriculture, Washington, DC
Ranges based on Quantiles

K.7

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



Index of Delivered Sediment

- Data Not Applicable
- 0.01 - 0.69
- 0.70 - 2.58
- 2.59 - 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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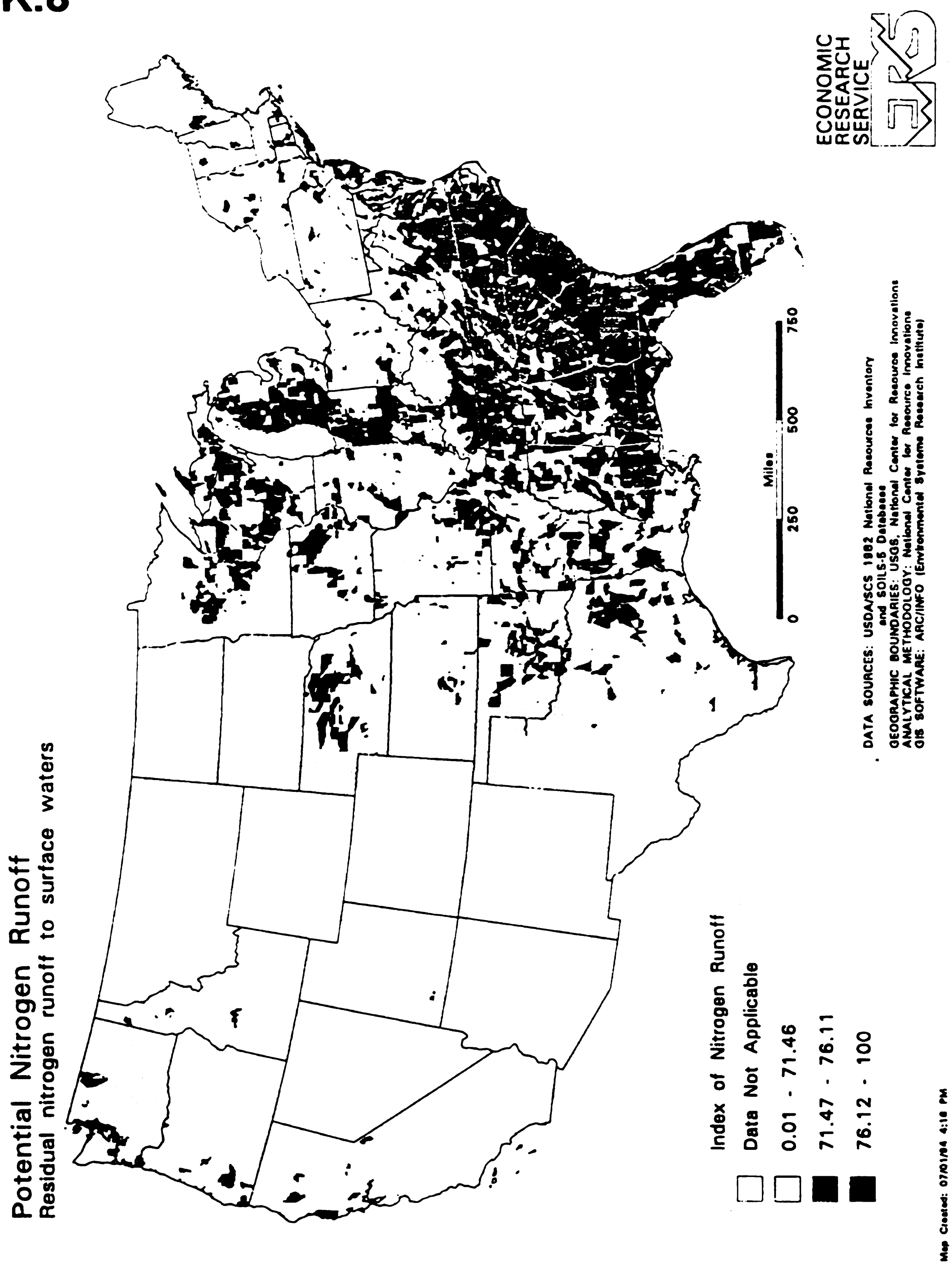
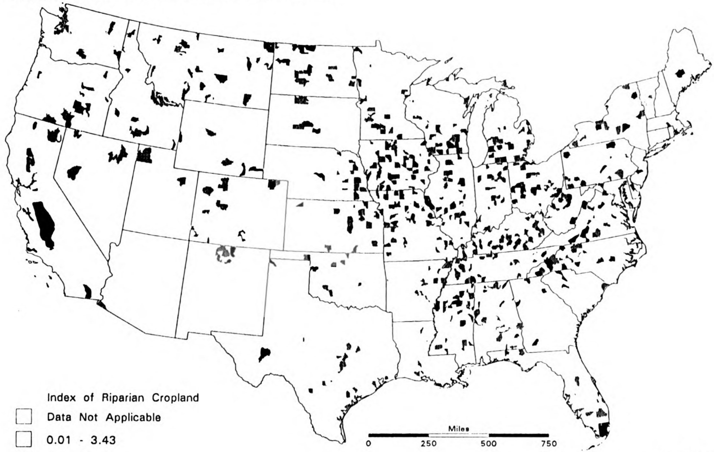
Map Created: 07/01/94 4:12 PM

K.8


Potential Nitrogen Runoff
Residual nitrogen runoff to surface waters
Index of Nitrogen Runoff
Data Not Applicable
0.01 - 71.46
71.47 - 76.11
76.12 - 100
Miles
0 250 500 750
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
Map Created: 07/01/94 4:18 PM

K.9

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



Index of Riparian Cropland

- Data Not Applicable
- 0.01 - 3.43
- 3.44 - 6.85
- 6.86 - 100

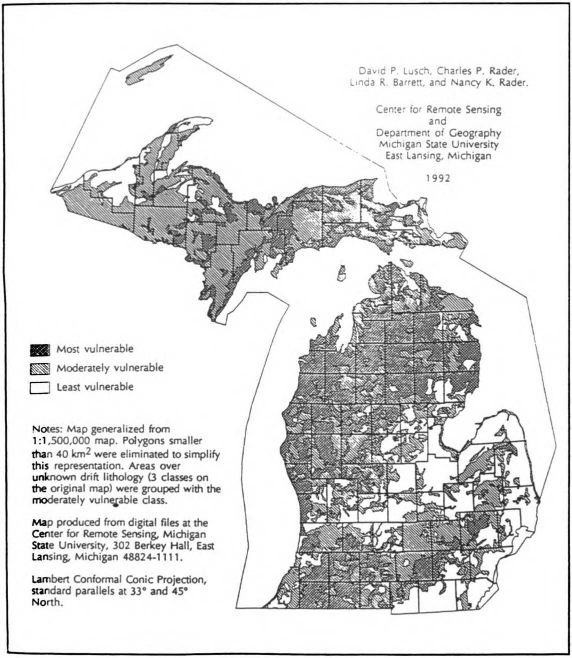
DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

ECONOMIC RESEARCH SERVICE

Map Created: 07/01/84 4:21 PM

K.10

Aquifer Vulnerability to Surface Contamination in Michigan.



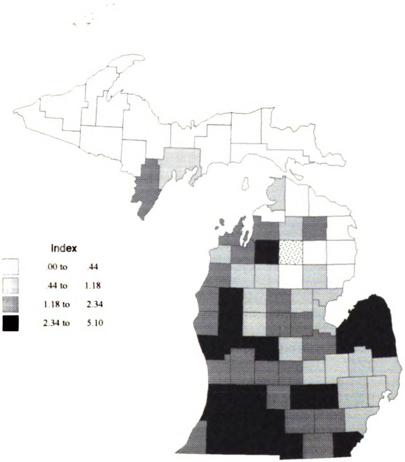
Appendix L

Maps of Environmental Problems Relating to Groundwater

L.1

Potential Nitrate Leaching

no weights applied

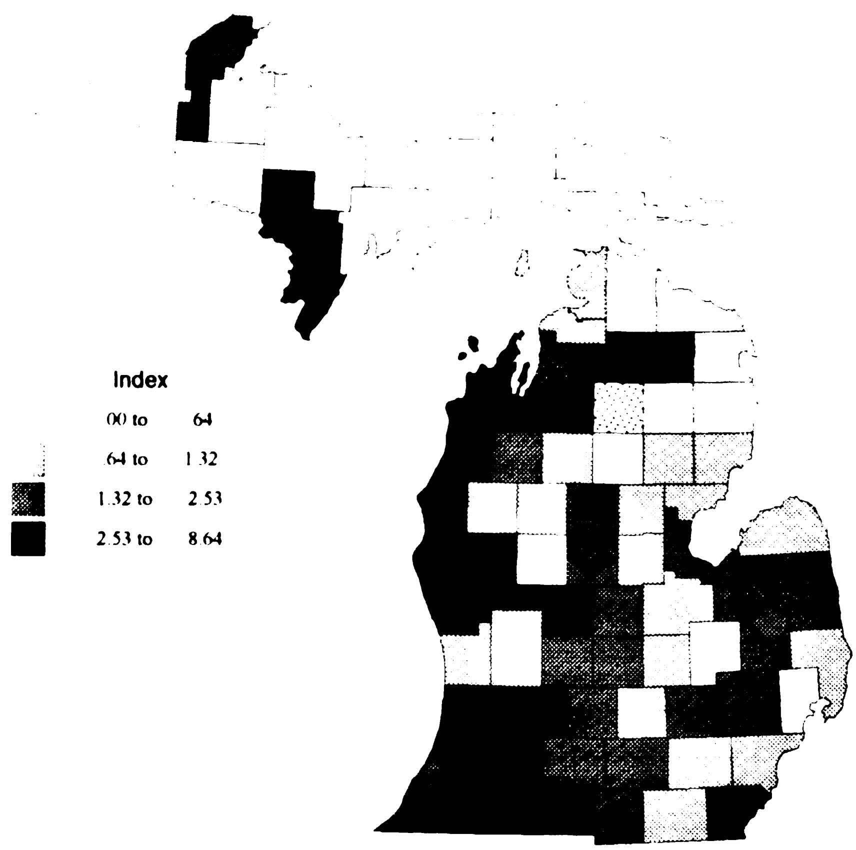


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

L.2

Potential Pesticide Leaching

no weights applied

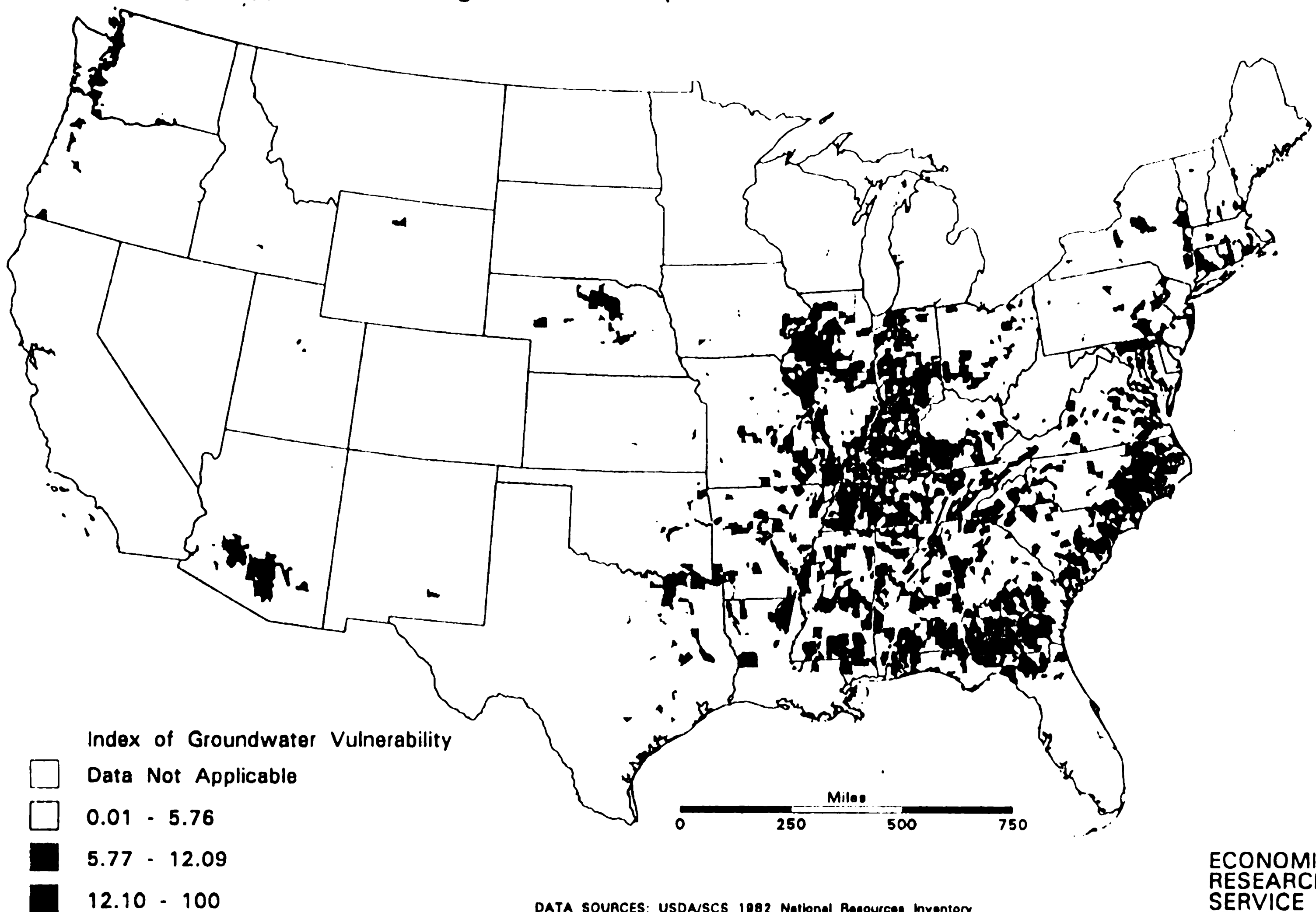


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

L.3

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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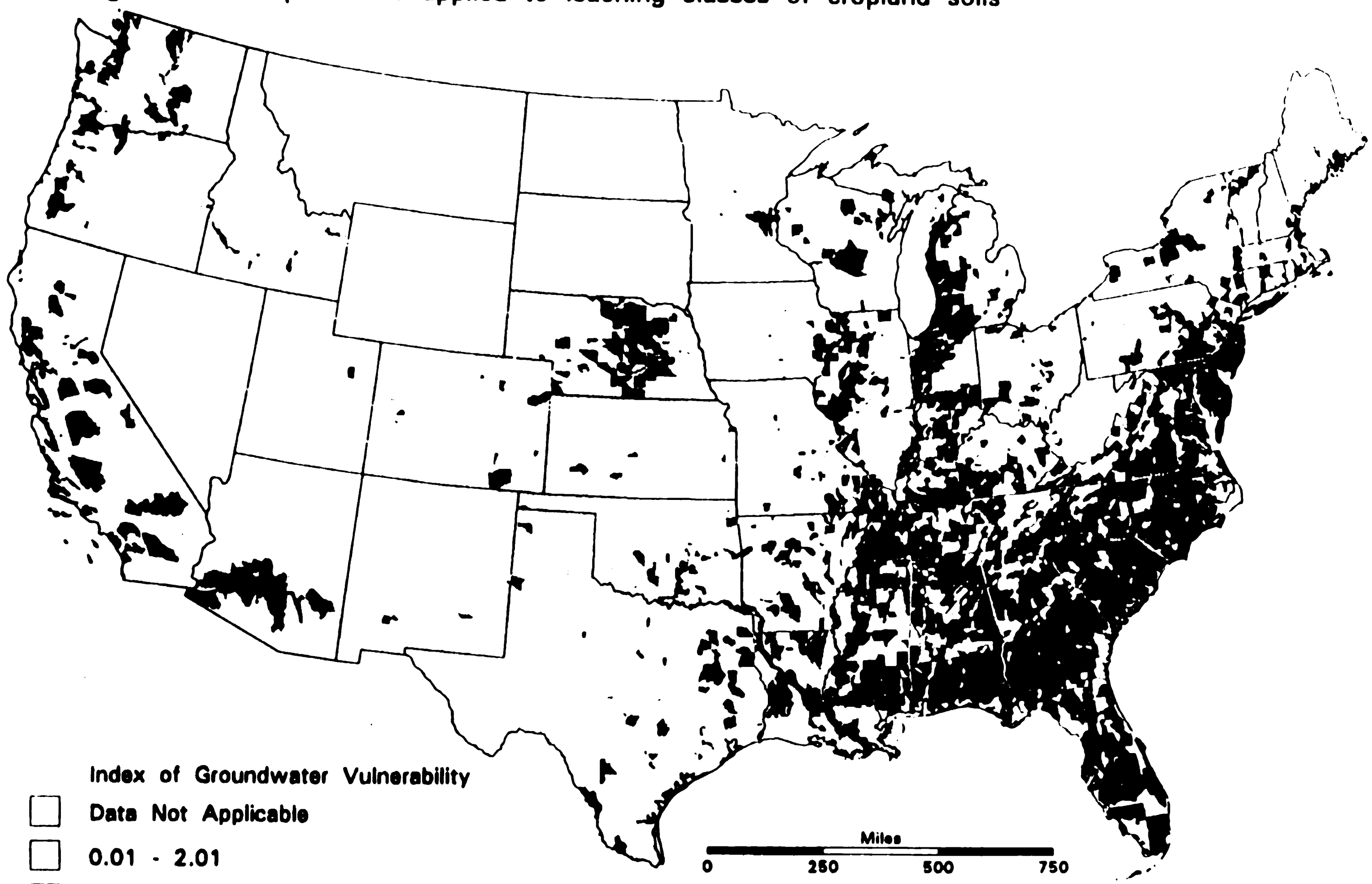
Map Created: 07/01/94 3:43 PM

L.4

Potential Pesticide Leaching

Leaching classes of pesticides applied to leaching classes of cropland soils



Index of Groundwater Vulnerability

- Data Not Applicable
- 0.01 - 2.01
- 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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Map Created: 07/08/94 11:34 AM

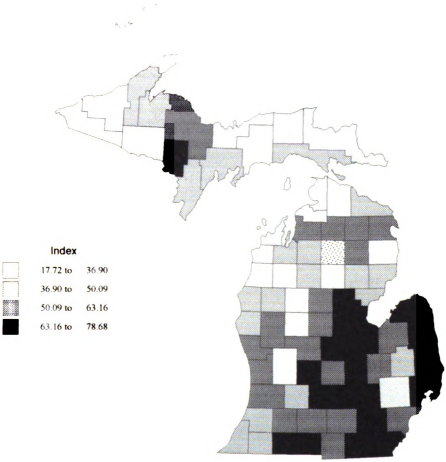
Appendix M

Maps of Environmental Problems Relating to Wildlife

M.1

Potential Wildlife Habitat Improvement

no weights applied

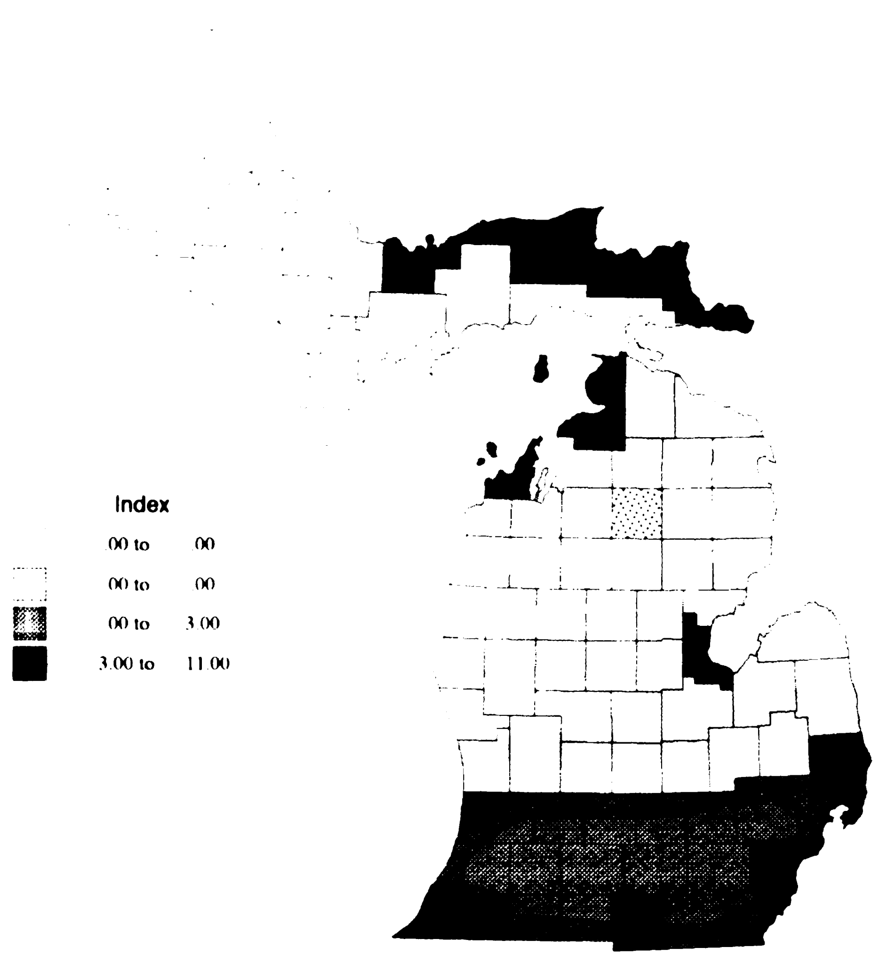


Economic Research Service, United States Department of Agriculture, Washington, DC
Index based on Quantiles

M.2

Number of Endangered Species

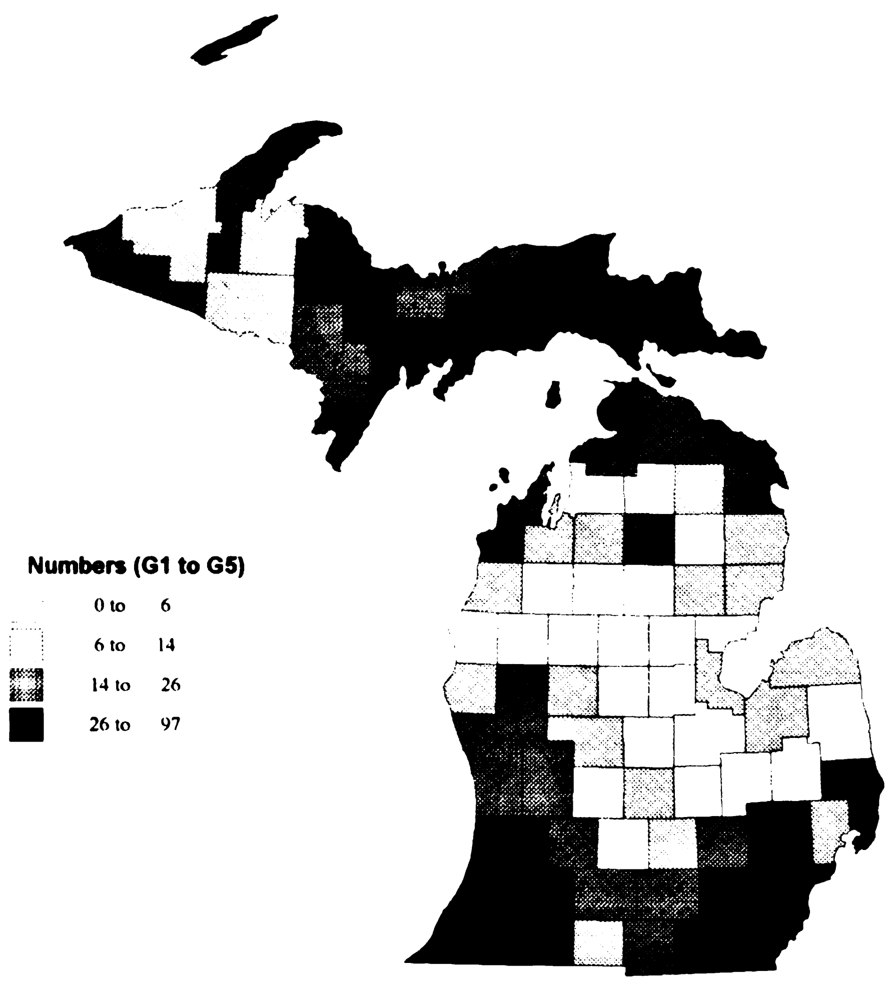
no weights applied



Economic Research Service, United States Department of Agriculture, Washington, DC

Index based on Quantiles

M.3
Status and Distribution of Rare and Endangered Plant and Animal Species



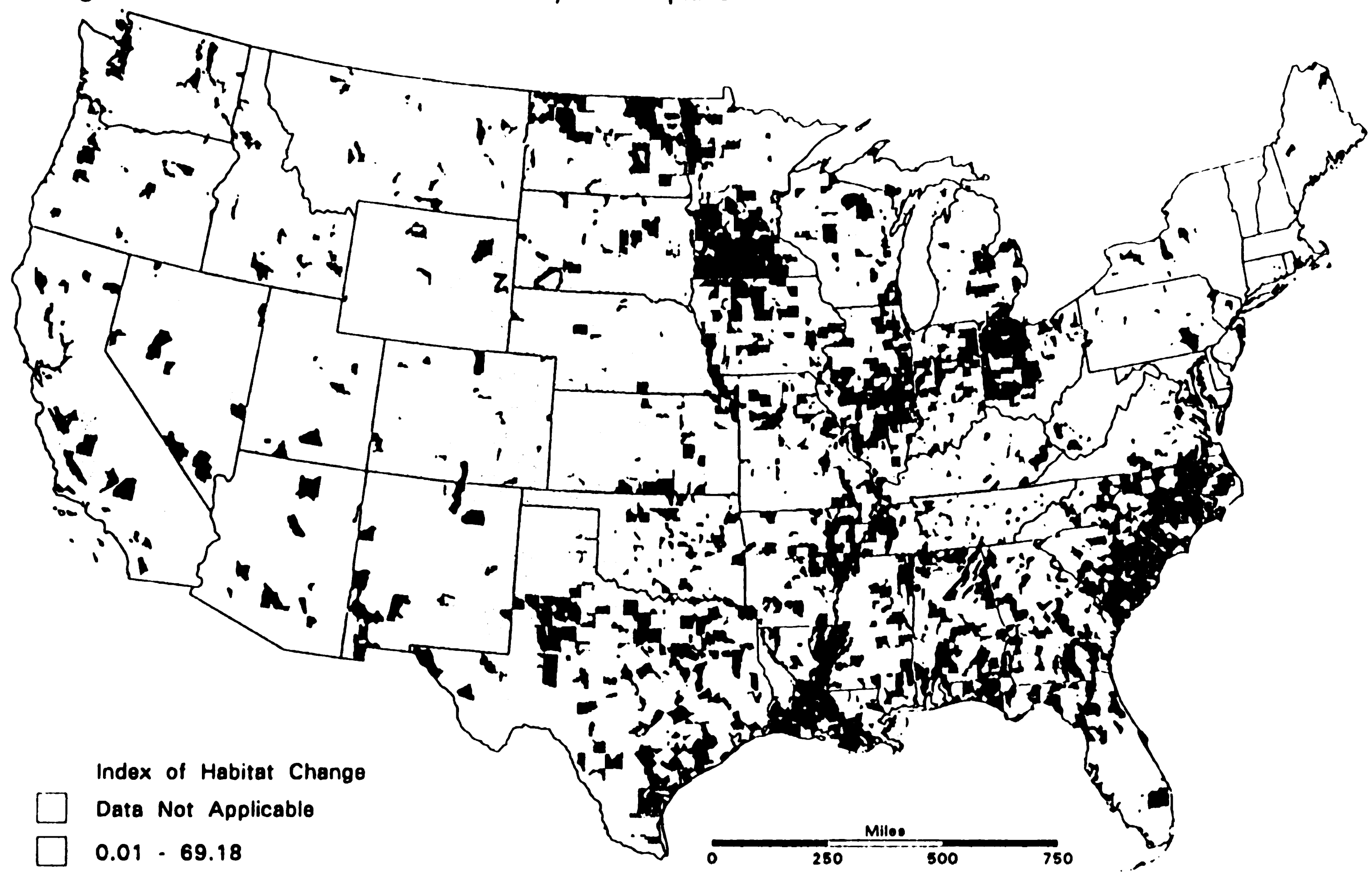
Michigan Natural Features Inventory, Michigan Department of Natural Resources, Wildlife Division

Ranks are established on a numeric rank (G1 to G5) of relative endangerment based on the number of occurrances of the species globally.

Numbers based on Quantiles

M.4

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



Index of Habitat Change
- Data Not Applicable
- 0.01 - 69.18
- 69.19 - 78.92
- 78.93 - 100

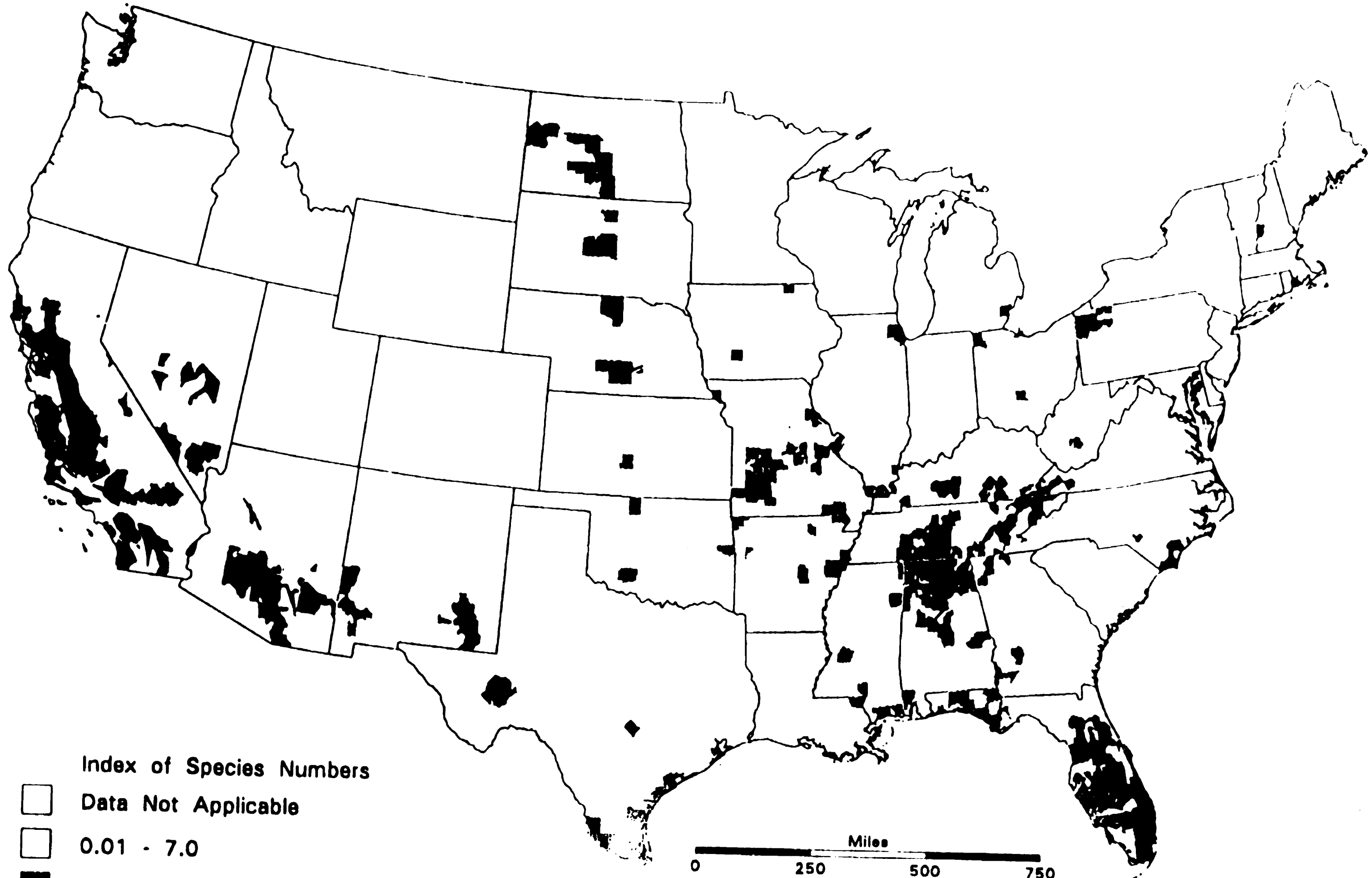
DATA SOURCES: USDA/SCS 1982 National Resources Inventory and SOILS-5 Databases
GEOGRAPHIC BOUNDARIES: USGS, National Center for Resource Innovations
ANALYTICAL METHODOLOGY: National Center for Resource Innovations
GIS SOFTWARE: ARC/INFO (Environmental Systems Research Institute)

ECONOMIC RESEARCH SERVICE

Map Created: 07/01/94 3:40 PM

M.5

Species Threatened and Endangered by Agricultural Development
Number of Species



Index of Species Numbers

- ☐ Data Not Applicable
- ☐ 0.01 - 7.0
- ■ 7.01 - 11.0
- ■ 11.1 - 100

DATA SO[illegible]ES: 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

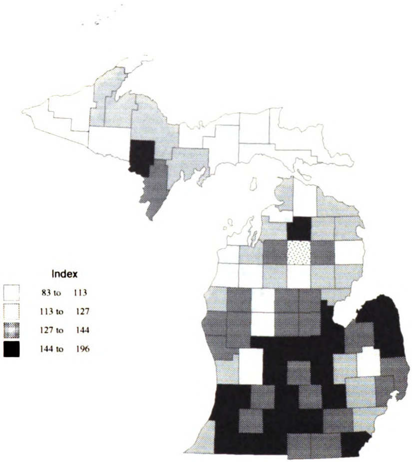
Map Created: 07/01/84 3:51 PM

Appendix N

Composite Maps of Environmental Problems

N.1

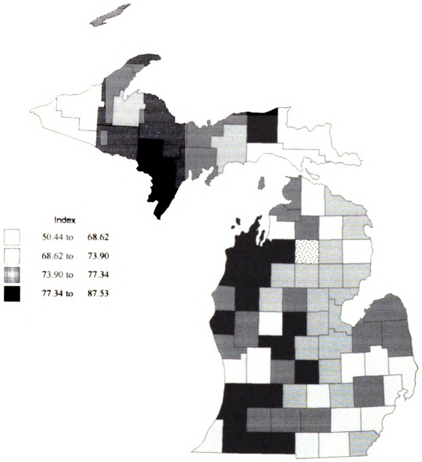
Composite Index of All Potential Problems



Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

N.2
Composite Map of all Surface Water Related Variables

(Potential for Sediment Delivery, Nitrogen Runoff, Filterstrips)

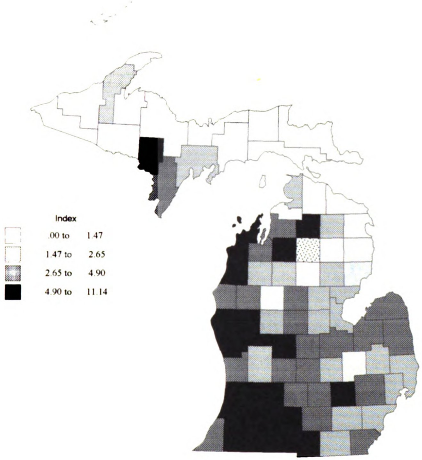


Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

N.3

Composite Map of all Ground Water Related Variables

(Potential for Pesticide Leaching, Nitrogen Leaching)

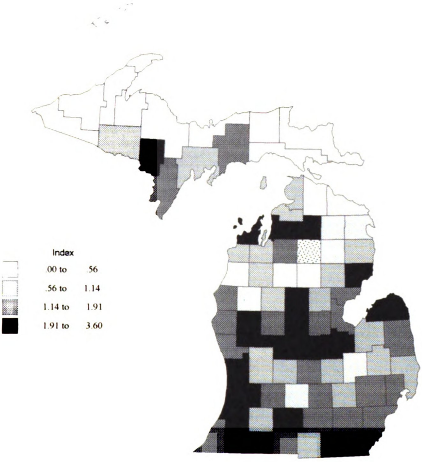


Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

N.4

Composite Map of all Soil Erosion Related Variables

(Potential for Soil Productivity Loss, Windblown Dust)

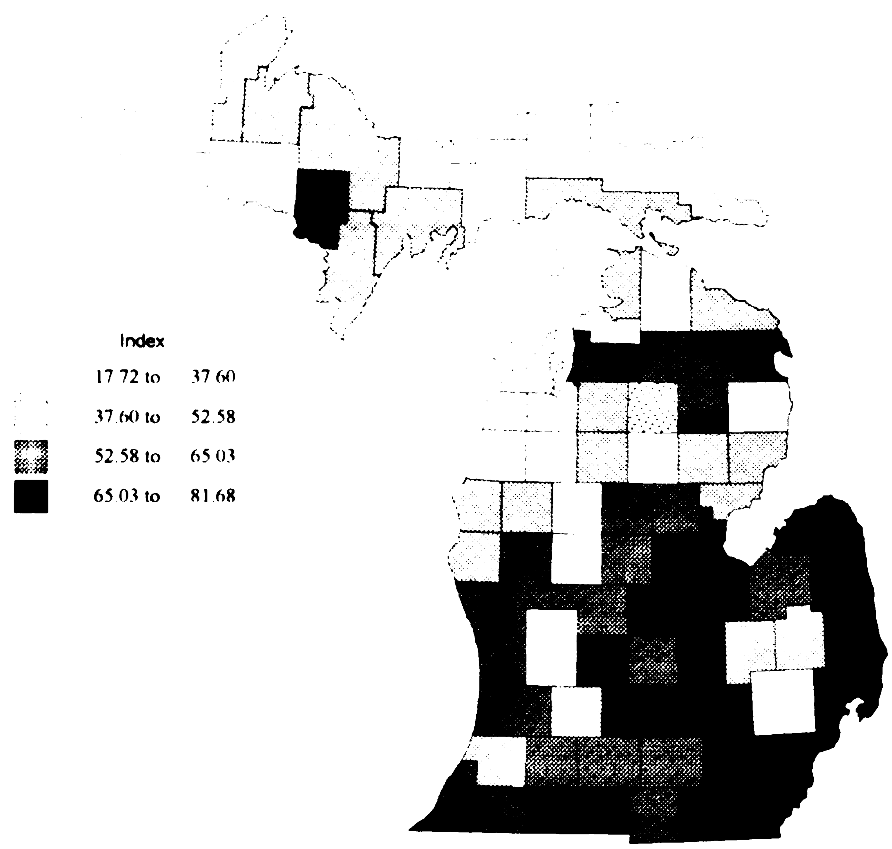


Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

N.5

Composite Map of all Wildlife Related Variables

(Potential for Wildlife Habitat Improvement, Threatened and Endangered Species)



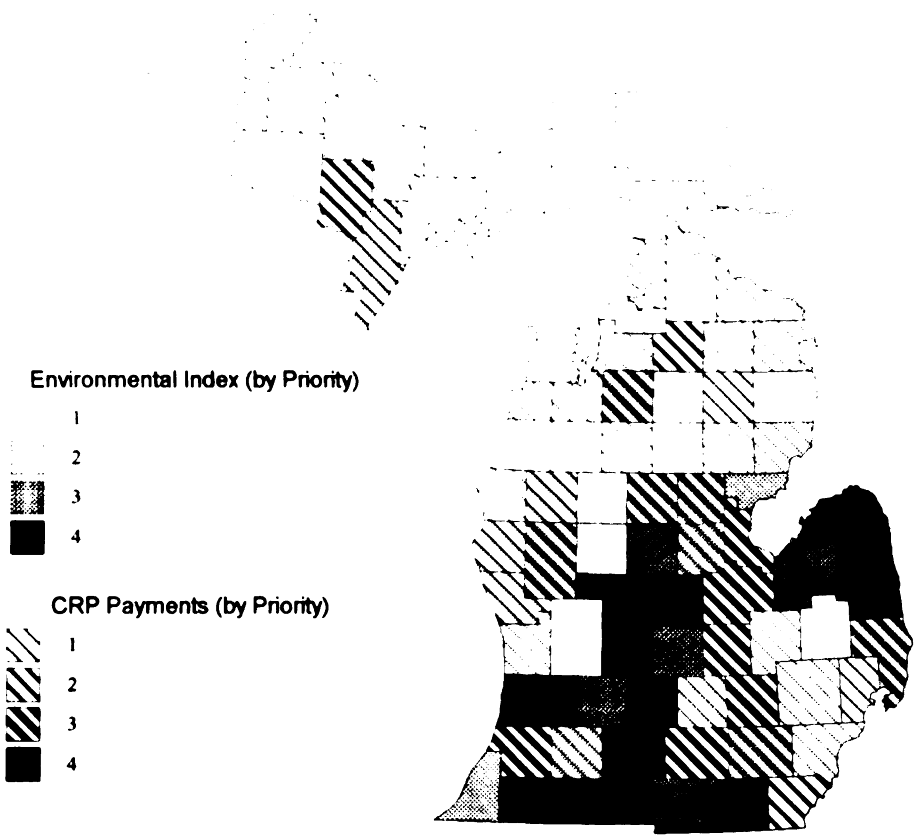
Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

Appendix O

Composite Maps on CRP Payments and Potential Environmental Problems

O.1

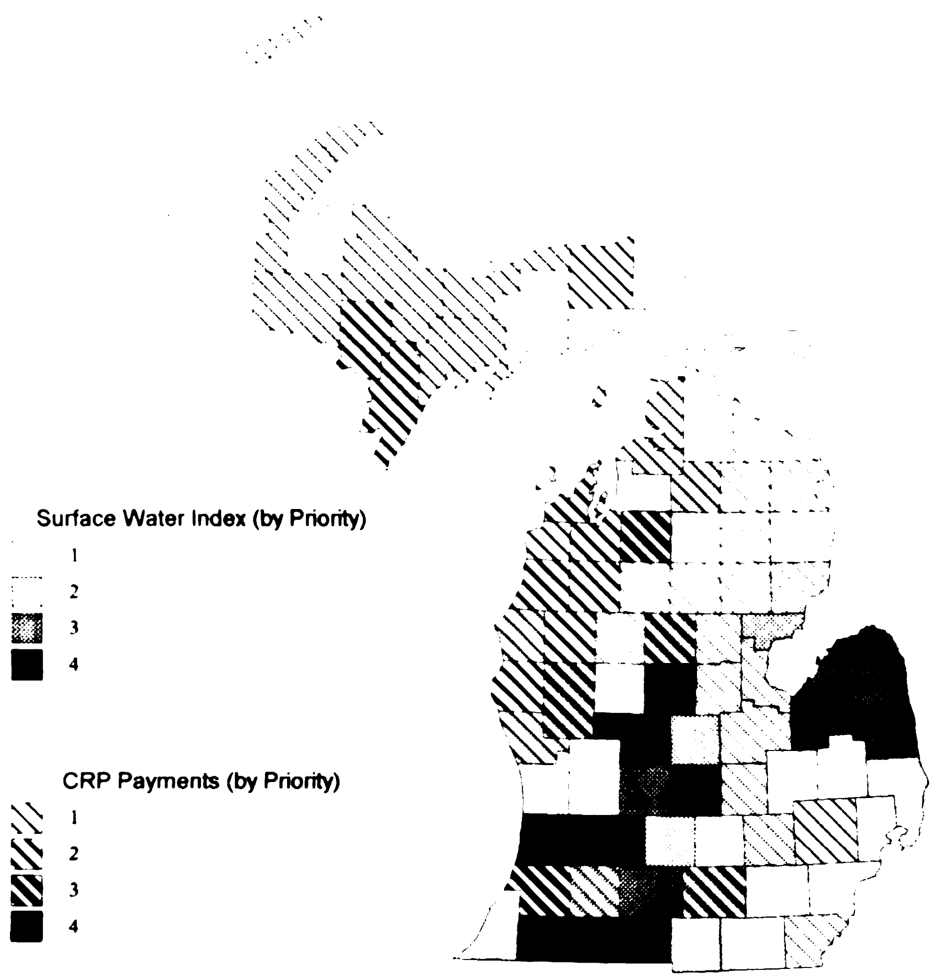
Combination of All Environmental Problems and CRP Payments



Environmental Working Group, Washington, DC
Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

O.2

Combination of Potential Surface Water Variables and CRP Payments



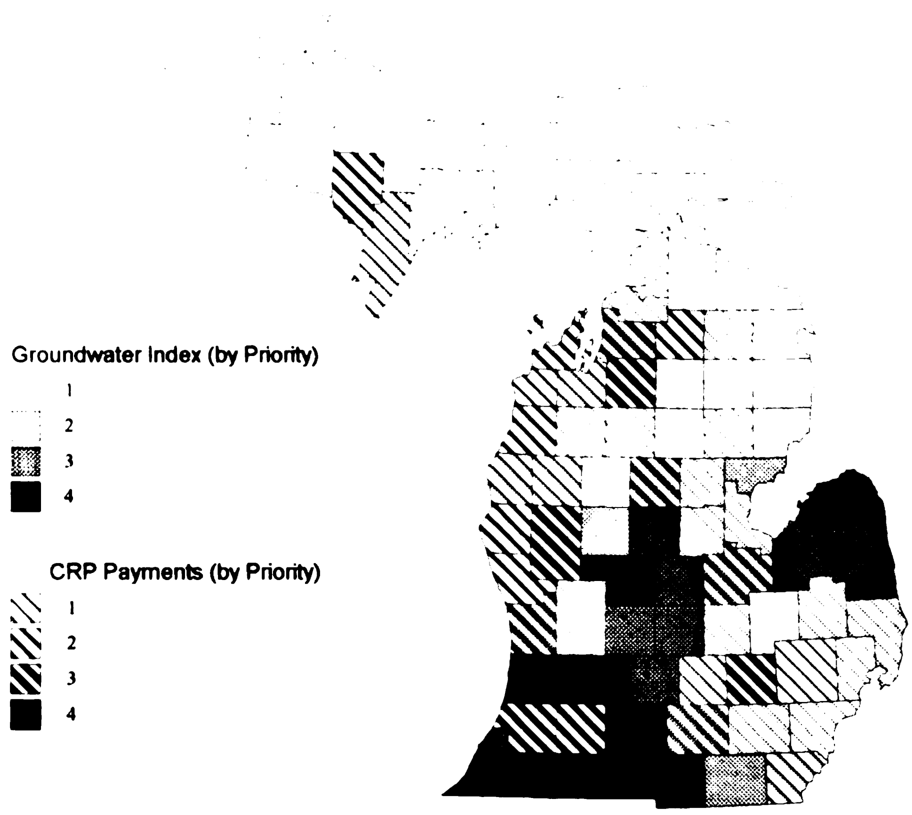
Environmental Working Group, Washington, DC

Economic Research Service, United States Department of Agriculture, Washington, DC

Ranges based on Quantiles

O.3

Combination of CRP Payments and Groundwater Variables



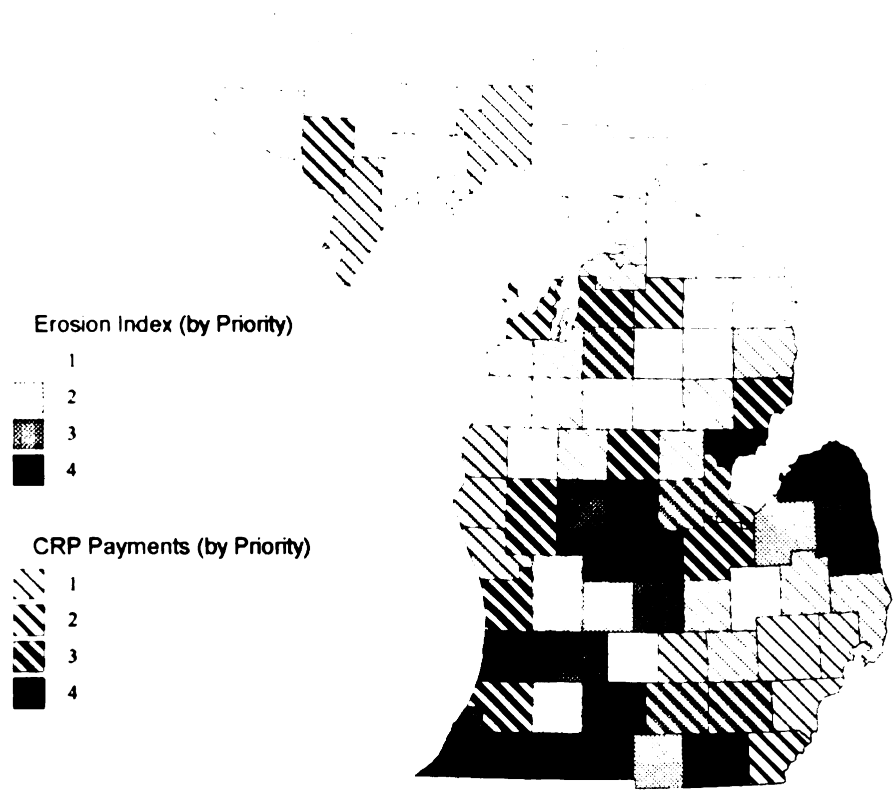
Environmental Working Group, Washington, DC

Economic Research Service, United States Department of Agriculture, Washington, DC

Ranges based on Quantiles

O.4

Combination of Soil Erosion and CRP Payments

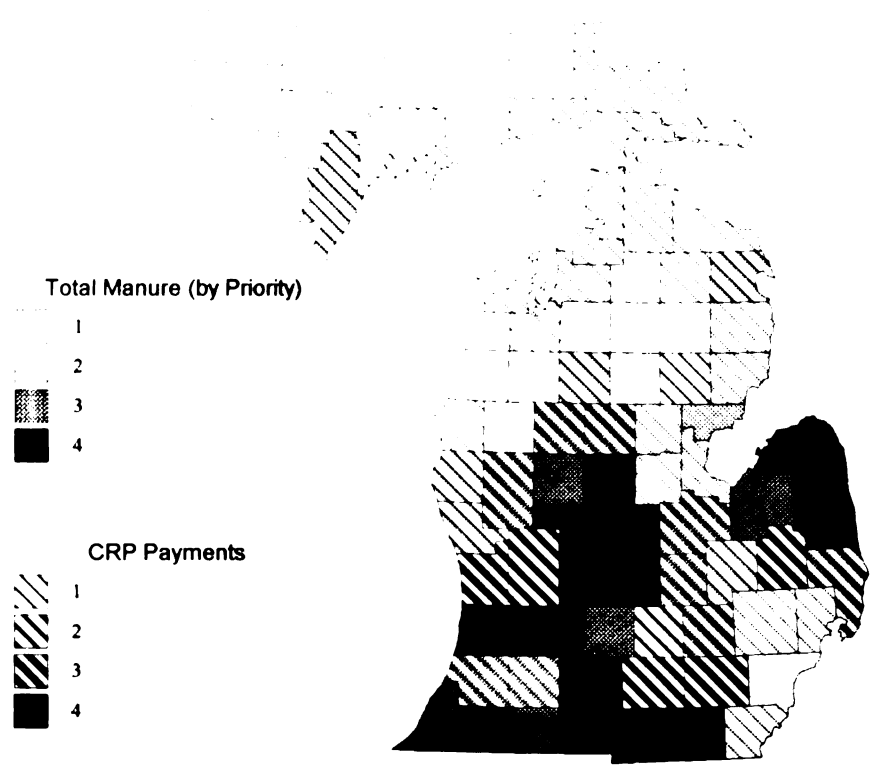


Environmental Working Group, Washington, DC
Economic Research Service, United States Department of Agriculture, Washington, DC
Ranges based on Quantiles

O.5

Combination of CRP Payments

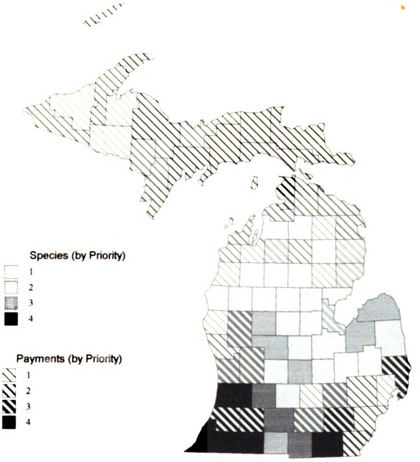
and Manure Production



Environmental Research Service, United States Department of Agriculture, Washington, DC
Manure management Sheets, Record keeping System for Crop production, Cooperative Extension Service
Michigan State university, Extension Bulletin E-2344, 1993
Ranges based on Quantiles

O.6

Combination of CRP Payments and Endangered Plant and Animal Species



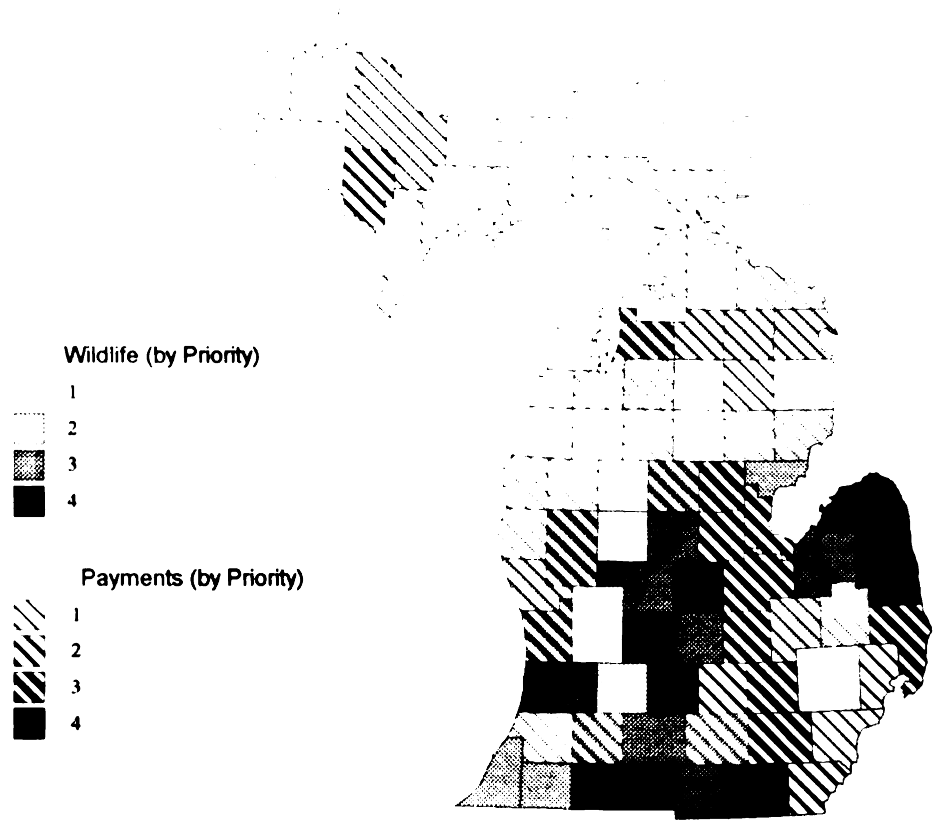
Environmental Working Group, Washington, DC

Michigan Natural Features Inventory, Michigan Department of Natural Resources, Wildlife Division

Ranges bsaed on quantiles

O.7

Combination of CRP Payments and Wildlife Habitate Improvement



Environmental Working Group, Washington, DC

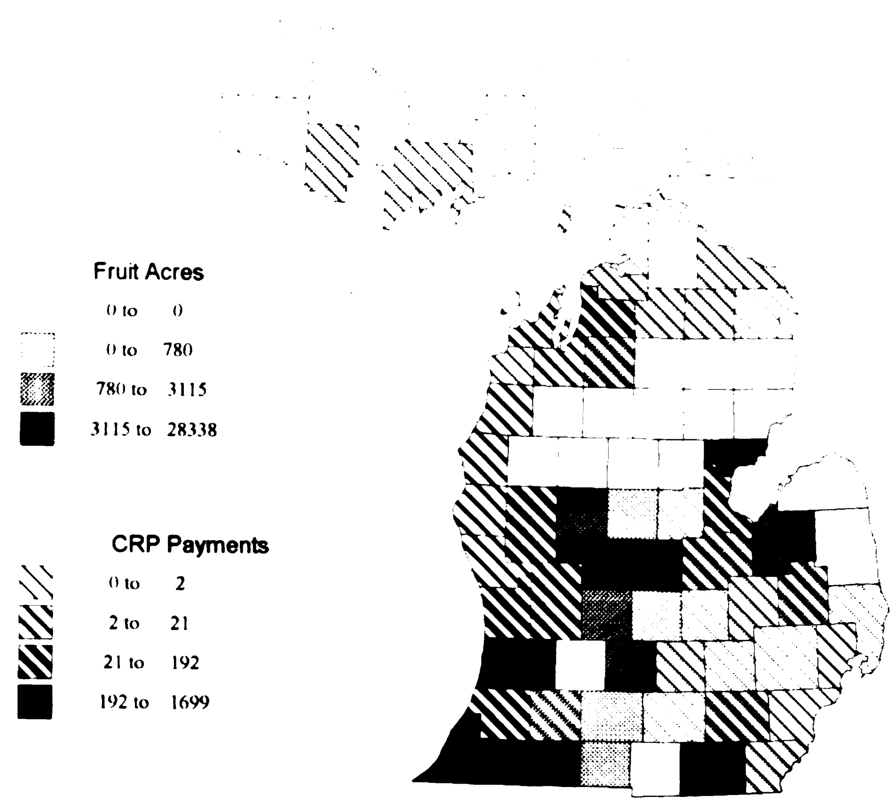
Economic Research Service, United States Department of Agriculture, Washington, DC

Ranges based on Quantiles

O.8

Combination CRP Payments

and Fruit and Vegetable Production



Environmental Working Group, Washington, DC

Michigan Rotational Survey, 1992

Ranges based on Quantiles

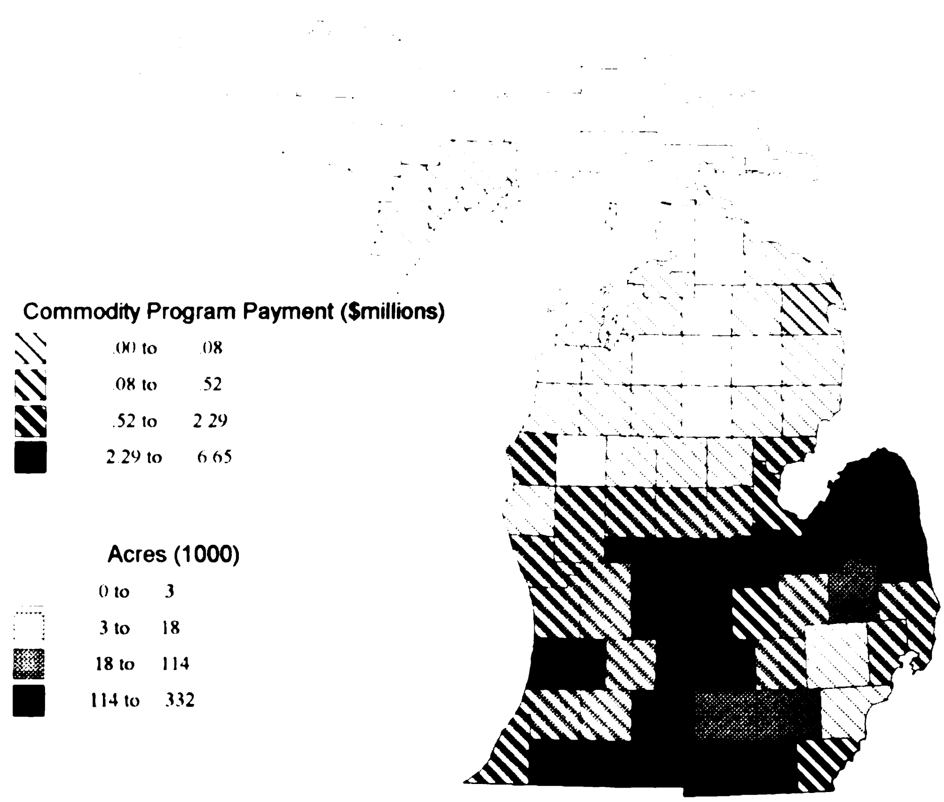
Appendix P

Commodity Program Payments and Agricultural Production

P.1

Commodity Program Payments

and Crop Production

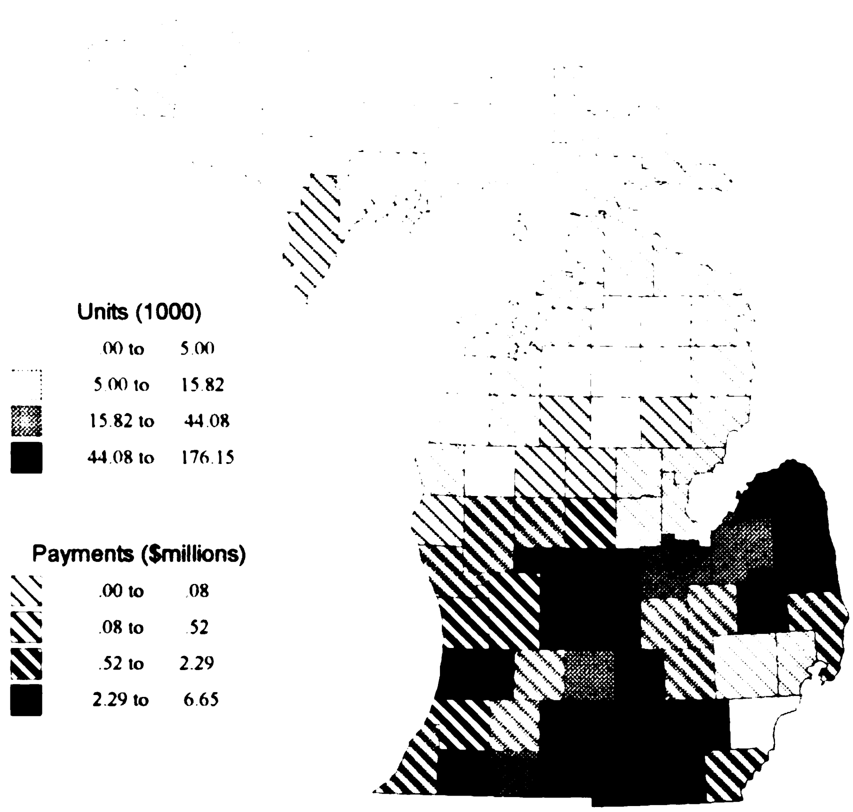


Economic Research Service, United States Department of Agriculture, Washington, DC
Michigan Agricultural Statistics, 1993
Ranges based on Quantiles

P.2

Commodity Program Payments

and Animal Units

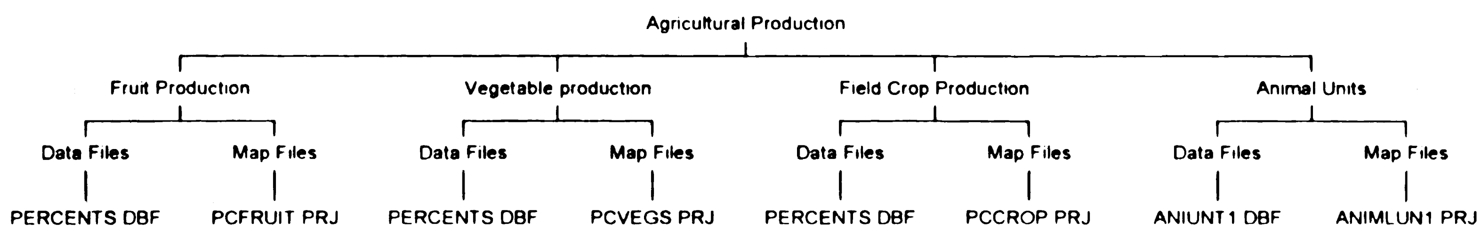


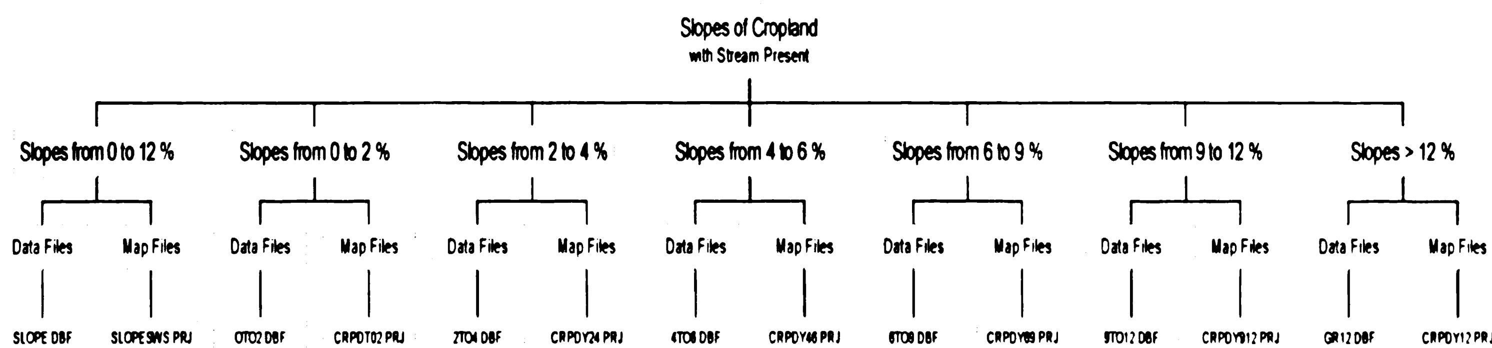
Environmental Working Group, Washington, DC
Michigan Agricultural Statistics, 1993
Ranges based on Quantiles

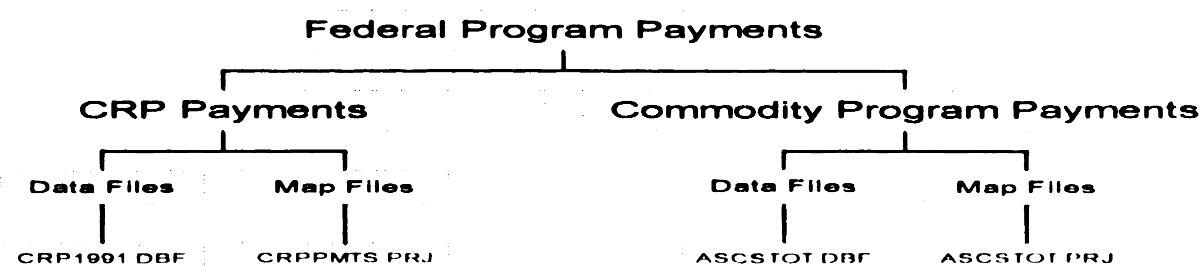
Appendix Q

Data and Map File Organization

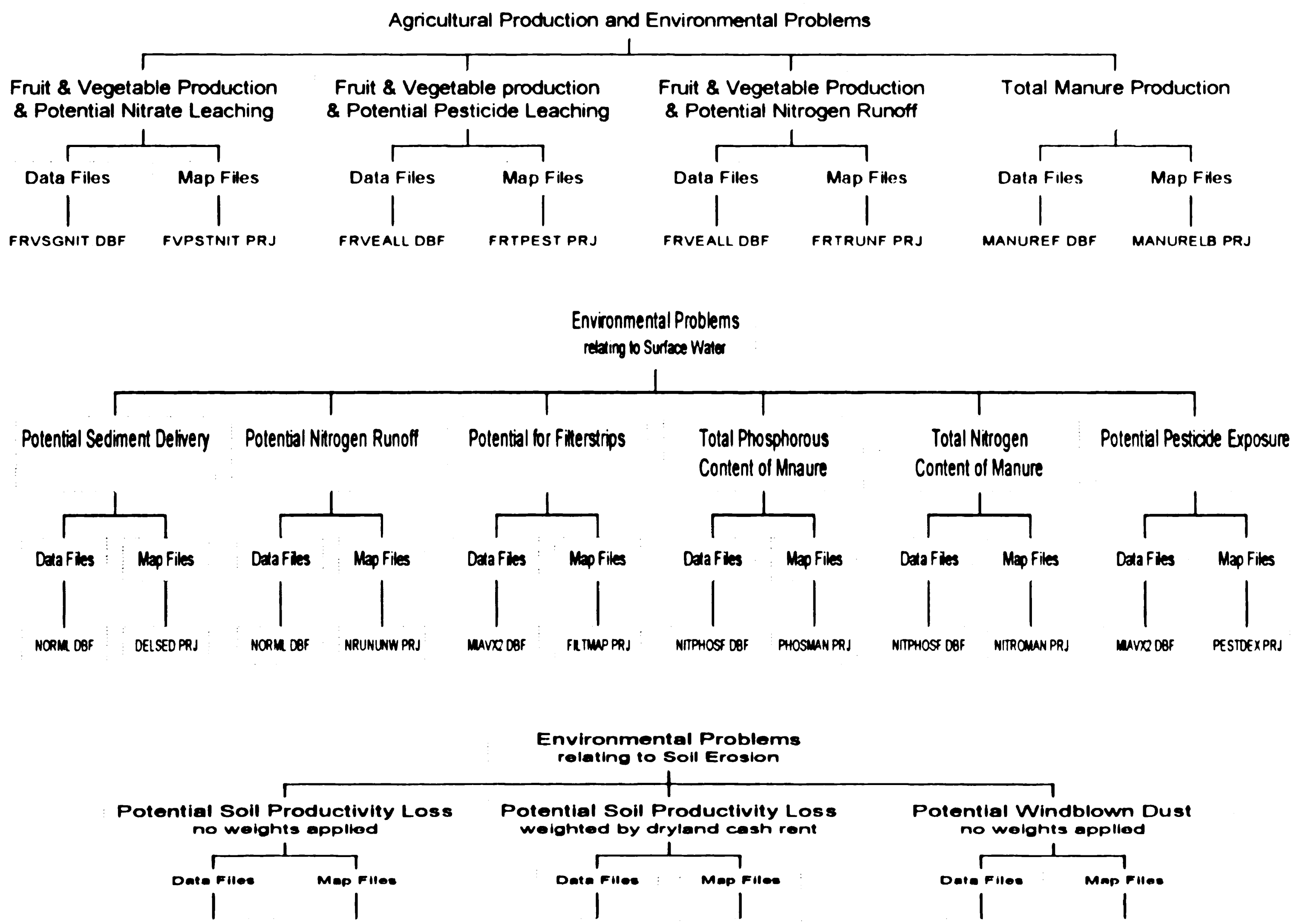
Q.1 DATA AND MAP FILE ORGANIZATION CHART 1



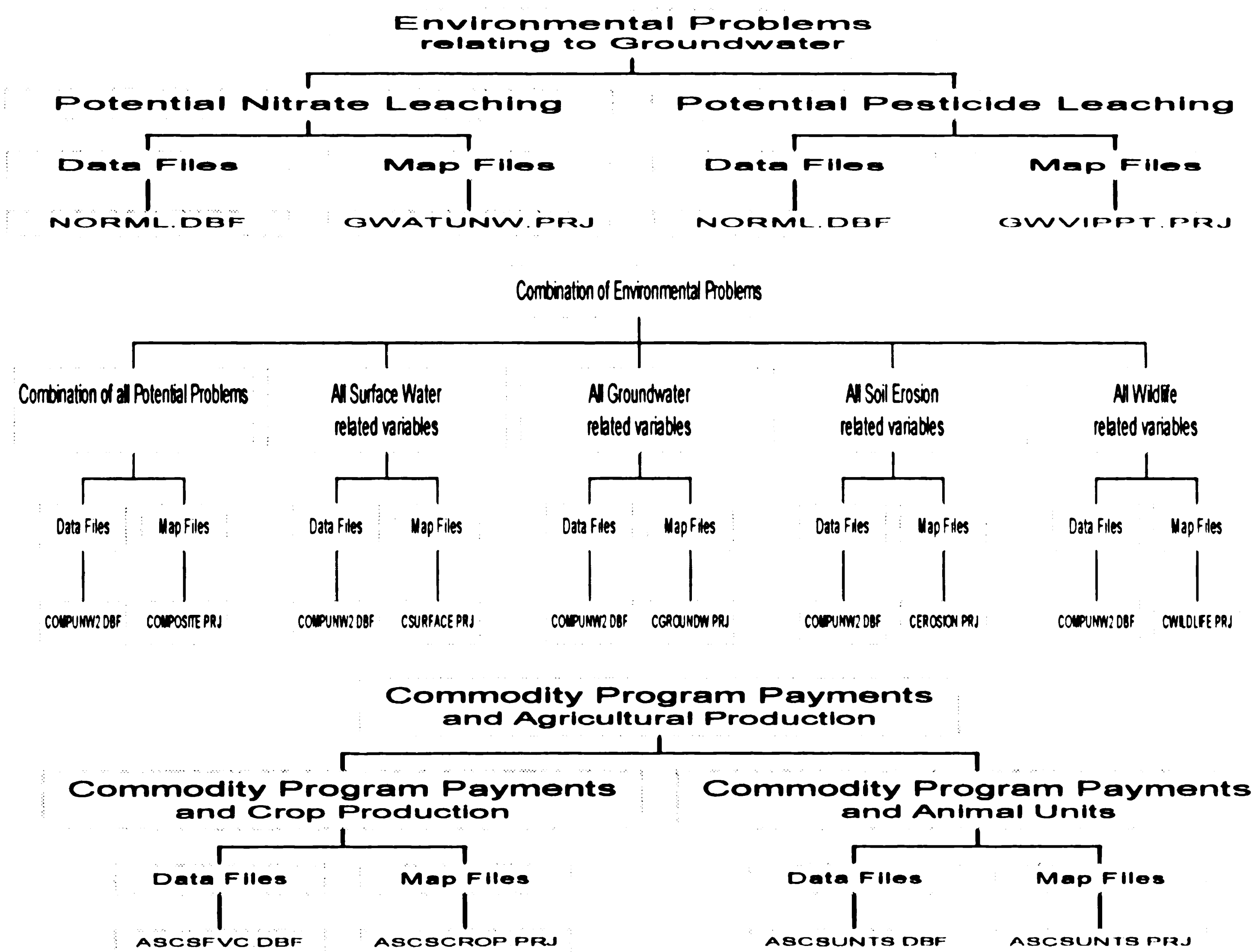




Q.2 DATA AND MAP FILE ORGANIZATION CHART 2



Q.3 DATA AND MAP FILE ORGANIZATION CHART 3



DATA AND MAP FILE ORGANIZATION 4