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AN EVALUATION OF OPTIONS FOR MICRO-TARGETING ACQUISITION OF CROPPING RIGHTS TO REDUCE NONPOINT SOURCE WATER POLLUTION

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These acknowledgements notwithstanding, all errors remain the responsibility of project investigators.

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SUMMARY

One of the objectives of recent soil conservation and land retirement programs in the U.S. has been to improve environmental quality. Several programs enabled by the 1985 farm bill explicitly list reduction of agricultural nonpoint source pollution (NPSP) among their objectives. Observers have questioned, however, the effectiveness of some programs in achieving specific environmental goals and have proposed changing the way such programs are implemented to better "target" environmentally sensitive areas. In this study, micro-targeting is defined as differentiating among individual land parcels in a watershed for program implementation.

This study examined several related questions:

1. To what extent can the cost effectiveness of programs be improved by micro-targeting for NPSP reduction within a watershed?
2. To what extent is it worth obtaining additional information about heterogeneous biophysical and economic characteristics of fields to implement such a targeted program?
3. Given limited resources, how should agencies allocate efforts between collecting information and program implementation?
4. Which variables characterizing watershed NPSP response provide the most useful information for determining improvements in cost effectiveness and under what circumstances do they make improvements?

The project investigators used a case study approach in which detailed data were collected for the Robinson Creek Watershed (RCW) located in southeastern Minnesota. The 11,000 acre RCW is primarily agricultural (typical of the surrounding region) and located upstream from a recreational lake experiencing sedimentation and nutrient problems. The primary focus in the study was downstream water quality, rather than on-site erosion. However, management controls were targeted <u>on-site</u> to achieve downstream water quality improvement. Sediment yield (and reduction) at the watershed outlet were used as a general index of NPSP status because of ease of estimation and because other water quality parameters depend highly on sediment status.

The unit of analysis used within the watershed is a 40 acre square parcel of land for which topographic, land management, and soils data were collected. This database was used to run a NPSP transport model (called Agricultural Nonpoint Source or AGNPS) to simulate the effects of policy instruments that acquire some or all cropping rights on selected parcels of land.

The overall policy instrument simulated was a take-it-or-leave-it offer (hypothetically) made to landowners who respond by either enrolling the parcel (if the offer is sufficiently attractive) or continuing current management practices (if it is not). Variations on this generic policy instrument were developed to examine the effects of: 1) varying the physical variables upon which to base targeting; 2) acquiring some but not all cropping rights; 3) basing the policy instrument on worst case versus current land management practices; and 4) using uniform versus parcel-specific opportunity costs of cropping rights in the payments offered. Alternative policies were simulated by solving corresponding mathematical

programming problems that, in turn, yielded a particular pattern of land management in the watershed as well as total sediment reduction at the watershed outlet. Each problem was solved for nine levels of budget constraints assumed to face the agency administering the program.

Qualitative results from the simulations are as follows:

1) Targeting based on environmental and/or soil productivity variability has potential for increasing cost effectiveness (defined as % sediment reduction/$ outlay).
2) In general, decreasing marginal cost effectiveness is exhibited as budgets increase.
3) The relative cost effectiveness of different targeting options is sensitive to the size of the budget.
4) Unbundling (imposing partial management restrictions on) cropping rights offers potential cost effectiveness gains over comparable full retirement options.
5) Micro-targeting offers potential cost effectiveness gains regardless of whether the base case is assumed to be current land management or the most erosive management conditions.
6) The range of magnitude of potential savings in government outlays for a given level of sediment reduction is sufficiently large to suggest that, when information acquisition and administrative costs are positive, micro-targeting is worthwhile under some budgetary and physical conditions but not others.

These results have several implications for design of federal land retirement legislation:

1) Design policy instruments to avoid disincentives for targeting (such as total national acreage goals) and provide positive incentives for targeting (such as substantive environmental improvement goals) in local program implementation.
2) Change land enrollment procedures to minimize overpaying or underpaying for cropping rights, such as by instituting competitive bidding.
3) Seek a better match of objectives with policy instruments.
4) Allow unbundling of cropping rights rather than full retirement only.

In addition, there are several implications for local implementation of federal legislation:

1) Use available information about landscape heterogeneity to the fullest extent to rank eligible parcels eligibility for payment offers.
2) Estimate ex ante the potential benefits of targeting to determine what data, if any, are worth collecting given the characteristics of a specific watershed.
3) Allocate budgets for targeting-related activities (data collection and analysis) relative to landowner payments for land management changes according to projected cost effectiveness gains from targeting.

Future research efforts could be directed to incorporating greater realism in the simulations, examining other policy instruments besides payments to landowners, analyzing trade-offs among multiple conservation objectives, seeking ways to improve the net benefits of targeting itself, and conducting field studies of the more promising simulated policies.

Chapter 1: Policy Background

1.1. Introduction

The policy background for this study can be viewed in terms of the decisions facing government in seeking to reduce nonpoint source pollution. The government must first determine what policy instrument (standards, taxes, subsidies, liability rules, etc.) are available to induce a reduction in NPSP. Second, the government must decide at what points to intervene in the pollution production process (input purchases, production technology, output, pollution emissions, damages, etc.). Third, the government must decide how to allocate control efforts among individual agents.

The policy instruments traditionally available to government to address pollution can be categorized along two dimensions--the nature of the legal or economic incentives involved and the point of intervention in pollution production processes. Figure 1 presents a matrix showing representative points along these two dimensions. Perhaps the most common policy instrument used in the U.S. to address air and water pollution (in the context of this matrix) is the imposition of physical emission standards.

With respect to the horizontal dimension, the alternative policy instruments have theoretical advantages and disadvantages with respect to social welfare that are well documented in the literature. In general, policy instruments that take into account differences in marginal costs of pollution control among agents (such as taxes and tradable permits) outperform those that do not (such as uniform emission standards).

Figure 1:

Matrix of Pollution Control Policy Instruments and Points of Intervention

Stages in Pollution Process for Possible Intervention	Policy Instrument: Physical Standards	Taxes	Subsidies	Marketable Permits
Production Inputs				
Production Processes				
Production Outputs				
Pollution Emissions				
Off-site Environmental Conditions				
Damages to Pollution Receptors				

While policy makers have been aware of the temporal and spatial externalities associated with farming in the United States for some time, the set of policy instruments available to address these externalities has been limited by historically allocated property rights. Thus, most of the policy instruments proposed have offered subsidies (either direct monetary payments or subsidized information services) to induce pollution-reducing behavior. While this report analyzes policy instruments that can be categorized as subsidies (in the sense of being positive, rather than negative, economic incentives), it does not address their welfare effects relative to other generic policy instruments.

Subsidies allow the actions of economic agents to be modified, even when current allocation of property rights is sufficiently entrenched to preclude government from forcing the modification. While subsidies have long been a fixture of agricultural policy, they have rarely been used to promote environmental policy, which has tended to use negative economic incentives or other coercive instruments to achieve its goals. Property rights assignments can be argued to be irrelevant from a social welfare perspective, suggesting that subsidies and taxes have symmetric social welfare results. However, differences may arise out of the incentive structure that each creates.[1]

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[1] With respect to land retirement, there are several ways that inefficiencies may arise out of the incentives created by subsidies. First, offering a subsidy for land retirement may distort farmers decisions on how to most cost effectively conserve soil (such as terracing versus land retirement). Second, large subsidies may affect overall cash flows to the extent that farmers stay in business who would not survive in their absence. Third, the combination of positive financial incentives and eligibility based on erosion levels may reward poor land stewardship in order to qualify for enrollment. Fourth, by obviating the need to incorporate environmental effects of food production in commodity process, subsidies do not allow the price mechanism to optimally allocate resources. Finally, farmers may have incentives to misrepresent private costs (such as for establishing plant cover) in an effort to gain higher

With respect to the vertical dimension in Figure 1, from an efficiency standpoint, the closer the correspondence between the objective and the point of intervention the better. For example, if the objective is conserve soil productivity, the policy instrument should be aimed at reducing soil loss in those locations where productivity is most threatened. Alternatively, if the objective is to reduce downstream eutrophication, the policy instrument should be directed to reducing the greatest sources of nutrients. In terms of this study, this decision relates to choosing on-site erosion (analogous to emissions) vs. downstream water quality (analogous to exposure or ambient conditions) as a point of intervention.

Given this framework for classifying environmental controls, policies have been enacted or proposed to intervene in farmer decisions regarding inputs, production processes, and outputs, as well as efforts to control emissions (soil erosion), ambient conditions (downstream concentrations of sediment and nutrients), and damages (adverse effects on receptors in different downstream locations). Several boxes in this matrix have thus been exemplified by federal legislation and/or are being contemplated at this time, some of which are discussed below. In this study, we examined only the intersections of the subsidy column with the rows corresponding to emissions and ambient conditions. However, our analytical framework could as well be applied to other combinations.

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payments.

Once established, subsidies are politically hard to abandon. The longevity of some agricultural program benefits has raised their status close to a property right. If land retirement payments achieve this status, income transfer effects could dominate policy decisions over the program's future, regardless of the achievement of social welfare goals.

1.2 Current and Future Conservation Legislation

Conservation Reserve Program

The Conservation Reserve Program (CRP) is authorized under provisions of the conservation title of the 1985 Food Security Act. The CRP is a hybrid of previous land retirement and soil conservation programs, in addition to having some novel features. Under the CRP, farmers agree not to produce crops on qualifying highly erodible land for ten years in exchange for annual rental payments. During announced enrollment periods, farmers submit bids to their county Agricultural Stabilization and Conservation Service (ASCS) office indicating the acreage and dollar amount per acre they are willing to accept in compensation for retiring the land. The ASCS later announces the maximum acceptable bid level for the multi-county pool in which the farm is located. Land must be bid at that level or lower to be eligible for enrollment. Since the maximum allowable bid in different pools has changed little, if any, since the program began, most farmers learned the allowable bid and now bid very close to the maximum. If a bid is initially accepted, the Soil Conservation Service (SCS) then verifies that the parcel fulfills erodibility and other requirements. In addition, participants must have an approved plan for permanent vegetative cover, for which the government offers up to 50% cost-sharing.

There are several objectives associated with the CRP. One is to conserve soil productivity for future generations. Another is to improve surface and ground water quality by reducing runoff and use of farm chemicals. A third is reduction in environmental damages associated with wind erosion. The change in land use from crops to cover vegetation is intended to improve wildlife habitat quantity and quality and increase ecological diversity. Another objective is the opportunity of a guaranteed income supplement to farmers, some of whom have enrolled their entire farms. Last, but by no means least, is an objective of reducing surplus crop production.

Conservation Compliance and Other Existing Conservation Programs

The Conservation Compliance (CC) provision of the 1985 Farm Bill is an example of a policy instrument that is based on a shift in pre-existing property rights assignments. The shift, however, is only real if farm program benefits are treated as a property right. In terms of the matrix of environmental control interventions, CC comes closest to a production tax. That is, CC causes farmers to receive less money per unit of output if they "pollute" than if they do not. However, the CC "tax" is not closely correlated with the amount of pollution, giving rise to potential inefficiencies. Farmers make a binary decision of whether or not to avoid the tax based on whole-farm, not marginal, penalties and compliance costs.

Under current CC rules, cropping restrictions apply to all fields that are classified as highly erodible. The restrictions reduce the rate of erosion to some level. The decision faced by farmers is whether income is higher by participating (resulting in government program benefits but cropping restrictions) or by not participating (no program benefits but no cropping restrictions). The practices that enable farmers to avoid the tax vary by farm, as do the incentives and farmers' opportunity costs of participation.[2]

Fields can be brought into compliance by:

1) Crop rotations - opportunity cost of having to produce crops with lower or no net returns (lower yields, grass in rotation, etc.) and purchase of additional equipment necessary for new crops

2) Conservation Tillage - opportunity cost of yield decrease, higher production costs, and ownership cost of new or additional equipment required

3) Physical Conservation Measures - terraces, grassed waterways, strip cropping, etc. that have establishment and maintenance costs, hindrance to field operations, and opportunity costs of land removed from production

4) Retirement - opportunity cost of foregone net returns from production minus CRP payment or other revenues

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[2] In Mower County, where almost all of the Robinson Creek watershed is located, conservation compliance requirements may include any of the following:

- -- corn tilled on contour with 50% residue
- -- no-till corn into soybeans
- -- rotations that include hay and conventionally tilled corn with 40% residue
- -- tillage with chisel plow and disking

While used elsewhere in SE Minnesota on steep sloping land, terracing is not generally required on highly erodible land in Mower County for CC. Rotations are also not being recommended by coordinators of a voluntary conservation plan for the Upper North Branch Root River (that includes Robinson Creek) because of anticipated resistance by farmers.

Farmers are heterogeneous with respect to factors that affect the CC participation decision. Factors that are positively correlated with a decision to participate are historic program crop yields, deficiency payments, CRP payments, and other program benefits. Factors that are negatively correlated with participation are set-aside requirements, per acre opportunity cost of set-asides, per acre opportunity costs of conservation cropping systems, and market prices (increases with decreased program benefits and increased opportunity costs). (Holloway) Like the CRP, CC divides those potentially affected into two groups. Instead of the groups being based on eligibility, however, the CC division is based on compliance or lack thereof. In this respect, it does not incorporate the full range of information available about management of land parcels that determines whether a farm is in compliance. Rather than switch on or off access to government payments according to farmer compliance with a conservation plan, payments could be restricted in varying degrees depending on the magnitude of downstream water quality effects associated with different cropping systems (as expressed through cover and practice factors).

Other Existing Federal Legislation

There are several other land and water conservation programs authorized either by the 1985 farm bill or other legislation. Sodbuster and swampbuster provisions of the 1985 bill are similar to CC in the sense of being rather blunt instruments that do not relate financial penalties to the extent of noncompliance. Technical assistance and cost-sharing for conservation measures have traditionally been offered on a first-come, first-serve basis, although there has been some movement in the direction of differentiating among potential participants.

In addition to farm legislation, Section 319 of the federal 1987 Clean Water Act focuses attention on NPSP control from land runoff. To comply with this legislation, states must identify and develop management plans for high priority watersheds.

1.3. The 1990 Farm Bill

As of this writing, the 1990 federal farm bill has extended the original CRP with expanded land eligibility provisions for additional enrollment. Several million additional acres are being authorized for enrollment with explicit consideration of surface water quality improvement. Parcel eligibility criteria are being relaxed to account for regional differences in environmental objectives in addition to erosion reduction. There is also explicit consideration of water quality objectives through a separate water quality reserve program. The discretionary authority for water quality objectives may be either at the Secretary or local level. Finally, there are provisions to improve cost effectiveness by acquiring less than full cropping rights, allowing lands to be bid out of the program, and acquiring permanent easement rights rather than limited-term contracts.

Any changes in the CRP at the federal level that allow more local discretion in program implementation will likely have several effects on local ASCS and SCS offices. Some local offices have been hard pressed to accommodate the increased workload from the CRP, even when they could adopt a purely reactive mode (Kozloff, 1989). To the extent that program changes require or enable greater differentiation among land parcels than has been the case thus far, there will be increased cost of information acquisition and analysis. There may also be increased administrative costs from more transactions with each potential participant and the need to overcome local resistance to unequal treatment of participants. In addition to possible increases in local implementation costs, contemplated changes in the CRP represent an incremental movement away from the traditional egalitarian concept of eligibility for agricultural programs that may be resisted by landowners and possibly by local USDA staff.

There are several other possible policy changes whose implementation could be relevant to the issues considered in this study. These include allowing greater flexibility in crops that can be planted on specific commodity program acres, limiting the maximum percent of program acres in any one crop, reducing outlays for farm price support and conservation programs due to budget deficits, continued erosion of traditional property rights assignments, more stringent enforcement of existing legislation such as conservation compliance, sodbuster, and swampbuster, and controls on agrichemical inputs.

Chapter 2: Conceptual Framework

This chapter summarizes the conceptual background for this study. First, literature related to targeting is briefly reviewed. Next, theoretical conditions for efficiency are discussed. Finally, the accounting perspective used in this study is reviewed, with attention to reasons why it deviates from theoretical conditions.

2.1 Review of Literature Related to Targeting

Targeting soil conservation efforts within a watershed to reduce nonpoint source pollution has been studied by Duda and Johnson (1985) and by Maas et al., (1985). Duda and Johnson (1985) showed that targeting pollution "hot spots" such as streambank erosion caused by grazing, is more cost effective than uniform application of policy instruments. They suggested that targeting could be carried out by visual inspection.

Targeting among watersheds within a region or across the country has also been examined (Snell,1985; Gianessi et al., 1986; Ribaudo, 1986; 1989). Using a nationwide system of 99 watershed units, Ribaudo rated the units based on water quality measures and levels of different water resource uses. Targeting for these off-site factors was shown to be more cost effective than targeting simply on the basis of on-site considerations.

There are several studies demonstrating incremental benefits from targeting soil conservation efforts to maximize the reduction in on-site soil loss (Park and Sawyer, 1985; Raitt, 1986; Stults, 1987; Walker, 1983; and Lovejoy et al., 1986). In addition, the USDA Economic Research Service has published a series of reports on a pilot effort at targeting soil conservation programs (Nielsen, 1985). These reports generally concluded that targeting has the potential for increasing program efficiency in terms of tons of soil saved per program dollar expended.

At least one investigation has examined efficiency gains from targeting agricultural nonpoint pollution controls. Using a hypothetical targeting approach based on a case study from the Rural Clean Water Program, the authors found that program cost effectiveness could be improved up to 80% by targeting areas with the highest fine sediment loads (Setia and Magleby, 1988).

Two studies examine the effect of variable payments for conservation cost sharing. In one, the payments were based on off-farm sediment damage (Michaelson and Brooks, 1984). In the other, the variable payments were based on farmers' private benefits and costs from changing management practices (Kugler and Libby, 1985).

Jacobs and Casler (1979) examined the effect of a uniform versus a targeted <u>mandatory</u> policy instrument. They compared the effectiveness of a uniform reduction in phosphorus discharge a phosphorus effluent tax and found the tax to have greater social efficiency in achieving a given level of reduction.

Bouzaher et al. (1990) used dynamic programming techniques to compare a hypothetical most efficient central control of sediment with a uniform tax and with a uniform standard. They found that, while central control outperformed the two uniform policy instruments at all levels of control, the tax only outperformed the standard at certain levels of control. This discrepancy from economic theory was attributed to the nonmonotonic nature of sediment accumulation throughout a watershed.

As part of a larger study of the Conservation Reserve Program (CRP), AGNPS was used to simulate various hypothetical schemes for removing land from crop production (Kozloff, 1988). Targeting those cells that generated the highest sediment loads was found to reduce sediment loads by almost twice as much as the current CRP, for the same number of acres retired.

Not all research that addresses targeting issues are about targeting per se. Russell and Smith (1988) estimated the marginal and total benefits from three increasingly knowledge based approaches to environmental standard setting: 1) Benefits estimates were based on the change in the average regional water quality from imposing a uniform dissolved oxygen standards over an entire river. 2) The same uniform standard was imposed, but benefits were counted on only those reaches of the river not meeting the standard. 3) Individual discharges were reduced differentially and benefits were counted with full knowledge of how pollution is transmitted from several point sources to the different reaches of the river. The three approaches were tested under different standards. The results indicate that incorporating information about pollution transmission processes leads to more accurate benefits estimates than when such processes are ignored. Also, the differences in benefit estimates between 1), 2), and 3) were sensitive to the level at which the standard was set.

There is also a body of literature that may not use the term "targeting", but uses mathematical optimization techniques, such as multiple objective programming, to maximize some environmental policy subject to constraints (Haimes, et al., 1979; Boggess et al., 1980; Carvey and Croley, 1984; Setia, et al., 1988; Prato, et al., 1989; Robillard et al., 1980). While these investigations have different research objectives, they all seek to combine some physical model of soil erosion or nonpoint source pollution with an economic optimization model. Consequently, they offer methodological insights for developing a targeting evaluation framework.

2.2 Theory of environmental control

Targeting, as used here, is an application of the economic theory of the environmental control. In the simplest static model of environmental control, an optimal level of control is achieved when marginal social benefits are equated with marginal social costs. The level at which an environmental control is set in those simple models is based on its impacts on a representative average firm or consumer.

Setting an environmental control goal based on averages, however, may result in an inefficient use of society's resources. Not only are pollution-generating agents heterogeneous with respect to the costs associated with comparable reductions in emissions, but also pollution-receiving agents are heterogeneous with respect to benefits derived from a unit of emissions reduction. This is because the same level of emissions from two enterprises may result in different levels of exposure to humans or ecosystems, because the assimilative capacity of the environment varies geographically, and because society places a higher value on reducing exposure in some locations than others. Consequently, equal changes in emissions from different sources may cause different movements along a societal marginal benefits curve, depending on the type and magnitude of human activities in the location affected (Tietenberg, 1978; Nichols, 1984; Russell and Smith, 1988).

The use of a uniform control when different firms have different marginal benefit and marginal cost functions causes welfare losses because firms under or over allocate resources to pollution control. The steeper are the functions, the greater the welfare loss associated with uniform controls (Kolstad, 1987). For example, if the marginal increment in water quality benefits from each additional acre of land being retired is almost constant, the welfare losses due to a uniform eligibility standard control are less than if marginal benefits are rapidly changing with acreage retired. According to Kolstad (p. 397), "With benefits and costs changing rapidly in the vicinity of efficient emissions, errors associated with uniform regulation become more serious, resulting in significant changes in costs and benefits from just moderate changes in the output of each product".

When there are multiple polluting sources, the efficiency goal is served by seeking the following:

a. Allocate control efforts within each source to minimize the cost of a given level of damage reduction from the source;
b. Allocate control efforts across sources to minimize cost of total damage reduction from all sources; and
c. Strike a balance between benefits and costs of damage reduction (Nichols, 1984).

The first criterion arises when there are alternative means of achieving some level of damage reduction within the same source. In the context of this study, alternatives might include crop rotation, land retirement, minimum tillage, etc. The second criterion implies that opportunities for damage reduction be chosen in order of increasing marginal cost <u>across</u> sources as well as <u>within</u> sources. The third criterion requires that benefits be monetized and compared with costs of achieving a given level of damage reduction. This criterion was expressly omitted from the mandate of this research project. Excluding the third criterion, one could (and we do) posit acreage or monetary constraints on total control efforts for the watershed as a whole. Setting different constraints for individual watersheds implies some sort of comparison of potential damage reduction across watersheds (Tietenberg, 1978).

Although the above criteria generally favor policy instruments that differentiate among polluting sources, the salient characteristics of agricultural nonpoint source pollution of surface water deviate from the conditions under which these criteria suffice for maximizing efficiency. First, as discussed earlier, property rights allocations (and also transactions costs) limit feasible policy instruments. Traditional property rights assignments regarding land resources limit government interventions to address environmental externalities largely to voluntary programs with positive incentives for participation. If the targeted policy instrument differentiates among potentially affected agents solely on the basis of public benefits, and if these benefits diverge from private benefits, the agents are likely to behave in ways that limit potential efficiency gains from targeting. The more separated the public and private streams of benefits are to potential participants in space or time, the more incentive they have to behave in ways that diverge from social objectives.

A profit-maximizing farmer will not participate in a voluntary program unless the economic incentive offered is greater than foregone revenue or some other private welfare measure. To maximize potential efficiency gains, however, a targeting scheme must obtain participation by those farmers whose lands offer social benefits that exceed social costs. The government thus faces a "principal-agent" problem in that it must take the outcomes of farmers' behavior into account in establishing a targeted policy instrument. The need to consider individual farmers' private decision rules raises the cost of targeting by forcing the principal to obtain information on foregone private revenue (or other decision parameters) as well as on social benefits.

A second set of considerations follow from the presence of multiple sources of uncertainty and asymmetric information such that a watershed manager faces different sources and magnitudes of uncertainty than do farmers in the watershed (Shortle and Dunn, 1986; Milon, 1987; Segerson, 1988; McSweeney and Shortle, 1990). The sources of uncertainty from the perspective of the farmer include:

1) the effect of weather, pests, and soil erosion on crop yields;
2) input and output prices; and
3) future government programs.

These sources of uncertainty are also relevant to the watershed manager since they affect the farmer's reservation prices and thus whether a given farmer will participate in a given program offering.

The watershed manager faces the following sources of uncertainty:

1) the effect on farmers' reservation prices of direct and indirect input costs, management, transaction costs, risk attitude, and other factors;
2) noneconomic factors affecting farmers' participation decisions;
3) the relationship between actual downstream effects and those predicted by targeting variables;

4) the mix of storm events occurring over life of project that affect environmental benefits (prevented damages); and

5) government program budgets.

Achieving conditions that promote efficiency is further complicated if farmers and watershed managers are risk averse. From the manager's perspective, there is likely to be some minimum threshold level of water quality that must be achieved; otherwise, it is not worth spending any public funds in the watershed. Otherwise, with positive transaction costs, there is the possibility of an ex post decrease in social welfare from paying farmers to change land management practices. From the farmers' perspective, there is likely to be aversion to income variance. Thus, conservation programs that have the effect of reducing income variance are to be preferred over those that don't, all else equal.

2.3. Accounting Perspective

It is important to specify the accounting perspective used, since it can determine how empirical results are interpreted for policy implications. If a research goal was to evaluate the welfare effects of a given policy instrument, one would seek to compare the present value of social benefits and costs. The theoretical optimum is achieved when marginal social benefits equal marginal social costs. For example, in the context of the CRP, such an optimum might be achieved when the marginal water quality and other benefits from an additional acre of retired land equal the marginal costs to society in terms of the social value of foregone crop production and transaction costs.

In this study, the narrower research goal is to evaluate the nonmonetized water quality effects of targeting. Thus, alternative policy instruments are compared based on a single cost effectiveness criterion of percent sediment reduction at the outlet per dollar government outlay. The accounting perspective used here is different than that used in a typical benefit/cost analysis in several respects.

First, social benefits are not monetized so that, if multiple benefit categories were considered, some implicit or explicit set of policy weights would be required. However, only a single water quality objective is considered.

Second, opportunity costs are measured differently than in benefit/cost analyses that typically use a social accounting perspective. In a benefit/cost framework, the opportunity costs of land retirement would be primarily measured by the net social value of foregone crop production while government outlays would be considered only transfer payments. In our analysis, government payments to landowners are relevant opportunity costs under the presumption that such payments result in foregone opportunities for making payments on other land parcels or expenditures for other government programs. Public expenditures raised through taxes, however, may generate social opportunity costs by distorting the allocation of resources in the economy.

Because of government price supports and other farm programs, the social value of foregone crop production differs from private opportunity costs. The net social opportunity costs of foregone corn and soybean production in southeast Minnesota, for example, are probably less than private opportunity costs and may actually be negative (Kozloff, 1989). As well, government payments differ from true private costs unless landowners can be induced to reveal those costs. Regional disparities in CRP participation rates suggest that government payments are more compatible with private opportunity costs in some locations than others.

The distinction between social, governmental, and private measures of opportunity costs is policy relevant in that using one or another could generate different policy results. For example, if targeting is based on maximizing government cost effectiveness, the set of individuals who select themselves into a program may not be optimal from a social welfare perspective.

A third deviation from a benefit/cost framework is our use of ex post measures of program effects. When uncertainty about program benefits or costs exists before a program is implemented, a benefit/cost framework distinguishes between ex ante and ex post measures of benefits or costs. While uncertainty regarding both program costs and benefits is present here, a deterministic accounting perspective is used that does not differentiate ex ante from ex post values. That is, the decision regarding how much information to obtain for targeting is made ex ante (before program implementation). Our estimates of cost effectiveness, however, are calculated ex post, that is, as though all uncertainty has been resolved.

If the value of information is defined as the expected benefits of a more informed over a less informed decision (Chavas and Pope, 1984; Dasgupta and Heal, 1981), then the value of information required for different targeting schemes can be compared with the costs of obtaining it. Results presented in Chapter 4 enable alternative targeting schemes to be compared with respect to government expenditures required to achieve some level of environmental improvement. Our use of ex post values has policy implications since estimates reflect "potential" differences in cost effectiveness from using information for targeting. More realistic incremental decreases in uncertainty would yield more modest cost effectiveness gains than total elimination of uncertainty.

Finally, if the government is risk averse with respect to uncertain program effects, a program decision rule under benefit/cost analysis would be further modified to account for the effects of information on the variance in program effects. Our accounting framework does not incorporate this effect of information obtained for targeting.

Chapter 3: Data and Research Methods

For this project, we used a case study approach in which several hypothetical policy options are simulated using data from a Minnesota watershed. Results from a physical simulation model of NPSP transport are combined with economic data in an optimizing framework. Policy options represent alternative versions of a policy instrument in which some or all cropping rights are acquired in exchange for annual payments. Simulation results are then compared on the basis of cost effectiveness.

In this chapter, we first describe the watershed chosen as our case study. Next, we discuss the primary analytical tool and requisite data for simulating changes in nonpoint source pollution. We then evaluate the qualitative and statistical characteristics of candidate variables that could potentially be used for targeting policy instruments. In particular, we seek to identify characteristics to which the gains from targeting appear sensitive. Finally, we discuss the generic policy instrument used for the simulations and the general mathematical programming framework.

3.1 Description of Study Watershed

The 11,400 acre Robinson Creek Watershed (RCW) constitutes about 25% of the drainage area of the Upper North Branch of the Root River, located in Mower and Olmsted Counties southeast Minnesota. The terrain is flat to gently rolling. Land use is primarily agricultural, dominated by a two year corn-soybean rotation. There are about 40 farm management units in the RCW, of which 10 have livestock operations large enough to qualify as feedlots in a state database. A breakdown of land uses as of 1987 is:

corn (44.36%), soybeans (31.93%), oats (2.35), hay (11.84%), other (7.76%).[3]

In the RCW, land in cultivation increased from 73% in 1969 (MLMIS, 1988) to 82% in 1987, probably because of technological and market trends in agriculture. Figure 2 depicts the pattern of 40 acre cells that were at least 50% cultivated in 1987. Most of the noncultivated land area is in pasture and woods, land uses with low erosion potential.

An artificial impoundment of local recreational value, Lake Florence, is located just downstream from the RCW's outlet. Lake Florence has experienced sediment and nutrient problems for many years. The reach of the Root River between the outlet of the RCW and Lake Florence and Lake Florence itself have been identified as use-impaired by the Minnesota Pollution Control Agency (Division of Water Quality, 1987). Furthermore, a special USDA Soil Conservation Service project is focusing on the entire drainage area for Lake Florence (Soil Conservation Service, 1988).

3.2 Nonpoint Source Modeling Tool and Database

The first step in the study was to develop the database for the simulations. The economic and land management data collected consists of land management characteristics, soil productivity values, farm management units, costs of production for different tillage/rotation combinations,

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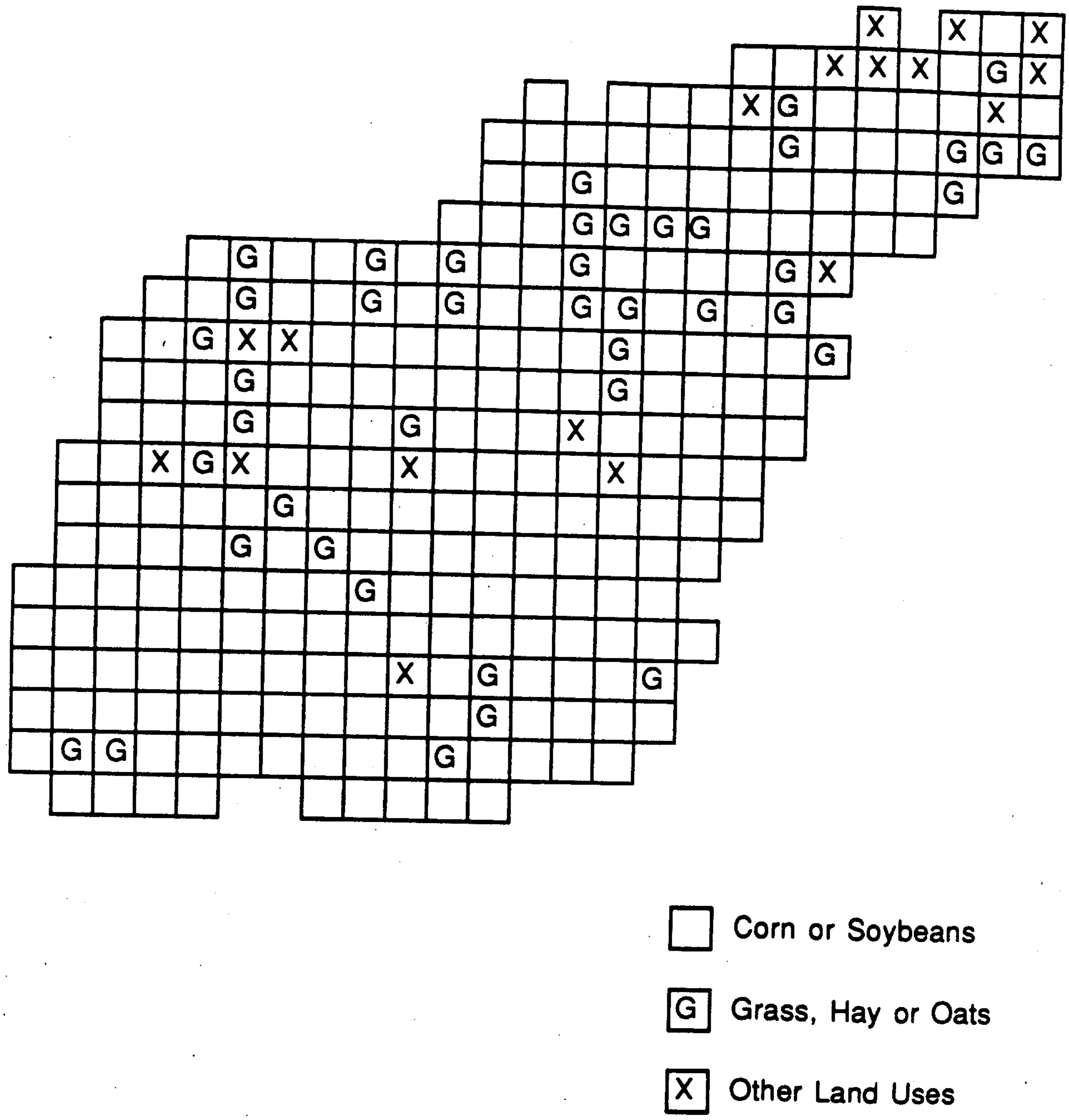
[3] includes other crops, grassed waterways, terraces, farmsteads, roads, woods, and set-aside acreage.

Figure 2. Simplified base case land uses by 40-acre cells in Robinson Creek Watershed, Minnesota.



sensitivity of crop yields to erosion by soil type, and participation in government programs.

Analysis of erosion and sedimentation processes in the watershed was conducted using the Agricultural Non-Point Source (AGNPS) model (Young et al., 1987; 1989). AGNPS is a watershed based model that was designed to simulate NPSP parameters for assumed rainfall events. The model uses a modified Universal Soil Loss Equation (USLE) for erosion generation (Wischmeier and Smith, 1978) and sediment transport algorithms that trace overland flow and sediment deposition through the watershed. Figure 3 displays the pattern of overland flow in the RCW, indicating the outlet cell to be in the uppermost northeast corner.

AGNPS requires input data on 21 variables listed in Table 1 for each 10 or 40 acre square cell within the watershed's boundaries. AGNPS provides output on the following NPSP parameters at both the watershed outlet and on a cell by cell basis: runoff volume, peak runoff rate, sediment-attached and soluble nitrogen and phosphorous, chemical oxygen demand, and tons of sediment in different particle size classes. A sample of AGNPS output for the outlet cell under 1988 land use (base case) conditions is shown in Table 2.

Four AGNPS input data sets for the RCW were obtained from the St. Paul office of the U.S. Soil Conservation Service. The different sets capture 1) sheet and rill erosion, 2) sheet, rill, and ephemeral gully erosion, 3) sheet, rill, ephemeral gully, and streambank erosion, and 4) sheet, rill, ephemeral gully, and streambank erosion, and feedlots. The 21 AGNPSinput variables were obtained by interpreting U.S.G.S. topographic maps, 1987 aerial photos, coupled with site verification. The SCS adjusted these data

Figure 3. Flow path in Robinson Creek Watershed used in AGNPS.

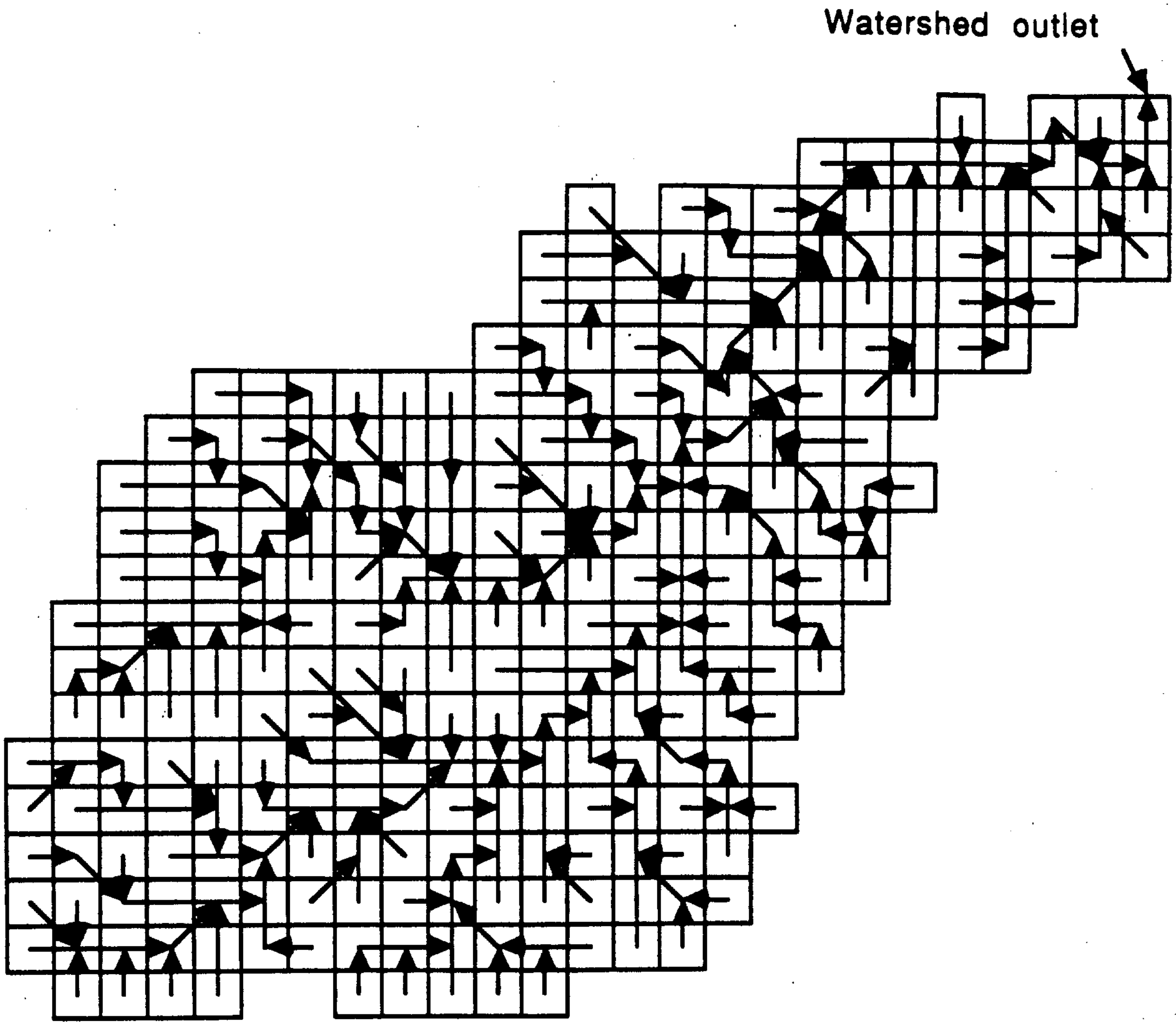


Table 1: AGNPS Input Parameters[1]

Watershed Data File

Sheet Number ________

Watershed Name ______________________________

Cell Number	Receiving Cell Number	SCS Curve Number	Land Slope %	Slope Shape Factor	Field Slope Length ft.	Channel Slope %	Channel Side Slope %	Mannings Roughness Coefficient for the Channel	Soil Erodibility Factor	Cropping Factor	Practice Factor	Surface Condition Constant	Aspect	Soil Texture Number	Fertilization Level	Availability Factor %	Point Source Indicator	Gully Source Level Tons	Chemical Oxygen Demand Factor	Impoundment Factor	Channel Indicator
XXX	XXX	XXX	XX.X	X	XXX	XX.X	XX.X	.XXX	.XX	.XX	X.XX	.XX	X	X	X	XXX	X	XXX	XXX	XX	X

Figure 1
Cell data collection sheet.

[1]Source: Young, et al., 1987

Table 2: Watershed Summary with Sediment and Nutrient Values at Outlet Cell

Oct 4, 1989

Watershed Summary

Watershed studied	UPPER NORTH BRANCH ROOT RIVER	
The area of the watershed is	11400	acres
The area of each cell is	40.0	acres
The characteristic storm precipitation is	4.0	inches
The storm energy-intensity value is	94	

Values at the watershed outlet

Cell number	4	
Runoff volume	1.8	in.
Peak runoff rate	2875	cfs
Total Nitrogen in sediment	5.47	lbs/acre
Total soluble nitrogen in runoff	4.41	lbs/acre
Soluble nitrogen concentration in runoff	10.82	ppm.
Total Phosphorus in sediment	2.73	lbs/acre
Total soluble Phosphorus in runoff	0.93	lbs/acre
Soluble Phosphorus concentration in runoff	2.28	ppm
Total soluble chemical oxygen demand	64.42	lbs/acre
Soluble chemical oxygen demand concentration in runoff	158	ppm.

Oct 4, 1989

Sediment Analysis

Particle type	Area Weighted Erosion Upland (t/a)	Area Weighted Erosion Channel (t/a)	Delivery Ratio (%)	Enrichment Ratio	Mean Concentration (ppm)	Area Weighted Yield (t/a)	Yield (tons)
CLAY	0.26	0.20	99	5	2231.59	0.45	5180.70
SILT	0.42	0.32	70	3	2530.47	0.52	5874.57
SAGG	2.62	1.99	22	1	4948.96	1.01	11489.17
LAGG	1.62	1.23	0	0	15.21	0.00	35.30
SAND	0.32	0.25	0	0	4.60	0.00	10.67
TOTAL	5.24	3.99	21	1	9730.82	1.98	22590.41

sets to be consistent with monitored in-stream flow data. We also checked the input values for internal consistency.

We ran the model for the four candidate input data sets for the RCW and two candidate storm events (5 and 25 year events). While our original intention was to use the annualized version of AGNPS, delays in the availability of that version limited us to using the most recent event-based version. We decided to use the input data set capturing all water erosion types as well as feedlot pollution and a 25 year storm event.[4]

Unless stated otherwise, the objective of the various policy simulations is to reduce total sediment (from all size classes) reaching the watershed's outlet cell. The relative "success" of different policy options is based on sediment reduction at the outlet over baseline conditions. In previous analyses, we found sediment-attached nutrient reduction to be highly correlated with sediment reduction. Because the numerical output values associated with pollutants from a 25 year event do not reflect annual values and because such values vary widely across watersheds, most of our results are presented in terms of percentage changes in sediment and nutrients. We implicitly equate changes in the outlet cell to changes in pollution receptors; ideally, however, the outlet cell would be linked to Lake Florence via a stream model.

[4]While a 5 year event gives outlet cell values that may be closer to annual rainfall, the 25 year event performed slightly better in differentiating cells for targeting purposes. The relative ranking among the cells in terms of nonpoint source pollutants was virtually identical for the two storm events as was the percent differences in outlet values between current conditions and changing individual cells. We note, however, that the choice of storm event can affect even the percent reduction in outlet values from changing land management input values in an AGNPS simulation (Prato et al., p. 16).

3.3 Analysis of Variables Considered for Policy Simulations

Because the nonpoint source modeling tool chosen requires data at the 40 acre level, this unit determined the level at which all other data were collected and analyzed. The use of 40 acre square cells as the unit of analysis has implications for how both physical processes and land management decisions are modeled. In watersheds with relatively sharp relief, a 40 acre scale could obscure runoff flow patterns and sediment deposition sites. While other parts of southeast Minnesota have such relief, this is not the case in the RCW.

With respect to land management decisions, 40 acres is similar to the size of many fields in southeast Minnesota. Since the rationale for targeting is related to the heterogeneity among land parcels, aggregating critical factors to a 40 acre scale could reduce the apparent benefits of targeting. For example, a cell might contain ten different soil types, each with different erodibility and productivity characteristics. In general, the greater the loss of modeling accuracy by aggregating data up to some uniform spatial scale, the smaller the scale should be. However, the smaller cells become, the more difficult it is to accurately reflect all differences in terms of information likely to be available. Furthermore, if public or private decisions are not likely to made for land parcels less than some size, further disaggregation may not be policy relevant.

The most serious potential source of bias in using uniform 40 acre cells as our unit of analysis probably arises from the lack of incorporation of "whole farm" decision factors. With an average size farm in the region being the equivalent of six or seven such cells, treating individual cells as separate decision units is unrealistic.[5]

Economic variables

Soil productivity values by 40 acre parcel are available in the form of Crop Equivalency Ratings (CERs) (Rust et al., 1984). The CERs are based on actual net returns per acre for the most commonly grown crops in the region and scaled so that the most productive soil in the state has a CER of 100. Each of the 35 soil mapping units present in the RCW has an associated CER. Each 40 acre cell in the RCW contains as many as ten soil mapping units, so a cell's CER is an average weighted by the acreage of different soil mapping units in it. CERs for the RCW range from 51 to 87 with a mean of 77.9. Thus, CERs averaged by cell exhibit less variation than do individual soils.

While CER values for soil mapping units do have crop prices at a point in time embedded in them, the variation among them is driven primarily by yields for the dominant crops grown on the mapping unit. Thus, to the extent that *relative* crop prices remain constant, CERs can be treated as indicators of relative physical productivity.

We used two variables as proxies for farmers' reservation prices necessary to induce a management change in a particular cell. For the

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[5] Because of fixed costs, livestock feed requirements, and other resource immobilities, the variation in our estimated reservation prices (due only to variations in soil productivity) over 40 acre parcels is likely to be different than the amount of variation in true reservation prices faced by farmers as a function of retiring a specific parcel of land. Consequently, actual land management changes may not occur when suggested by reservation price estimates, and vice versa.

first phase of our study, which focused only on land retirement, we chose a reservation price based on the average cash rent value for the region in which the RCW is located and adjusted for land productivity. We examined both county and statewide farmland rental value surveys to select for the base value. The cash rent service value is taken from iso-rent bars for agricultural land rents and ranged from 70 to 79 dollars per acre in the RCW (Kilgore, 1986). Figure 4 shows cash rent isolines for Minnesota. The factor we used to adjust the base value of $75/acre is defined as the CER for the cell in question divided by the average CER for all cells in the watershed.[6] The resulting set of reservation prices is not directly affected by cropping practices at a point in time, but rather, by long term soil productivity. This is consistent with simulating farmers' decisions regarding long term land retirement. For comparison, the current CRP (1989) Maximum Acceptable Rental Rates (MARR) for Mower County and Olmsted County, the counties in which the RCW is located, are $85 and $80, respectively.

For later phases of our study in which we considered land management changes other than retirement, we determined reservation prices somewhat differently than above. We examined three candidate sources of direct costs--field records from local farms (Olson, 1987), extension service recommendations for the soil region in which the RCW is located (Fuller, 1989), and statewide data compiled by McElroy et al., (1989). We used extension service recommendations since they include the largest set of

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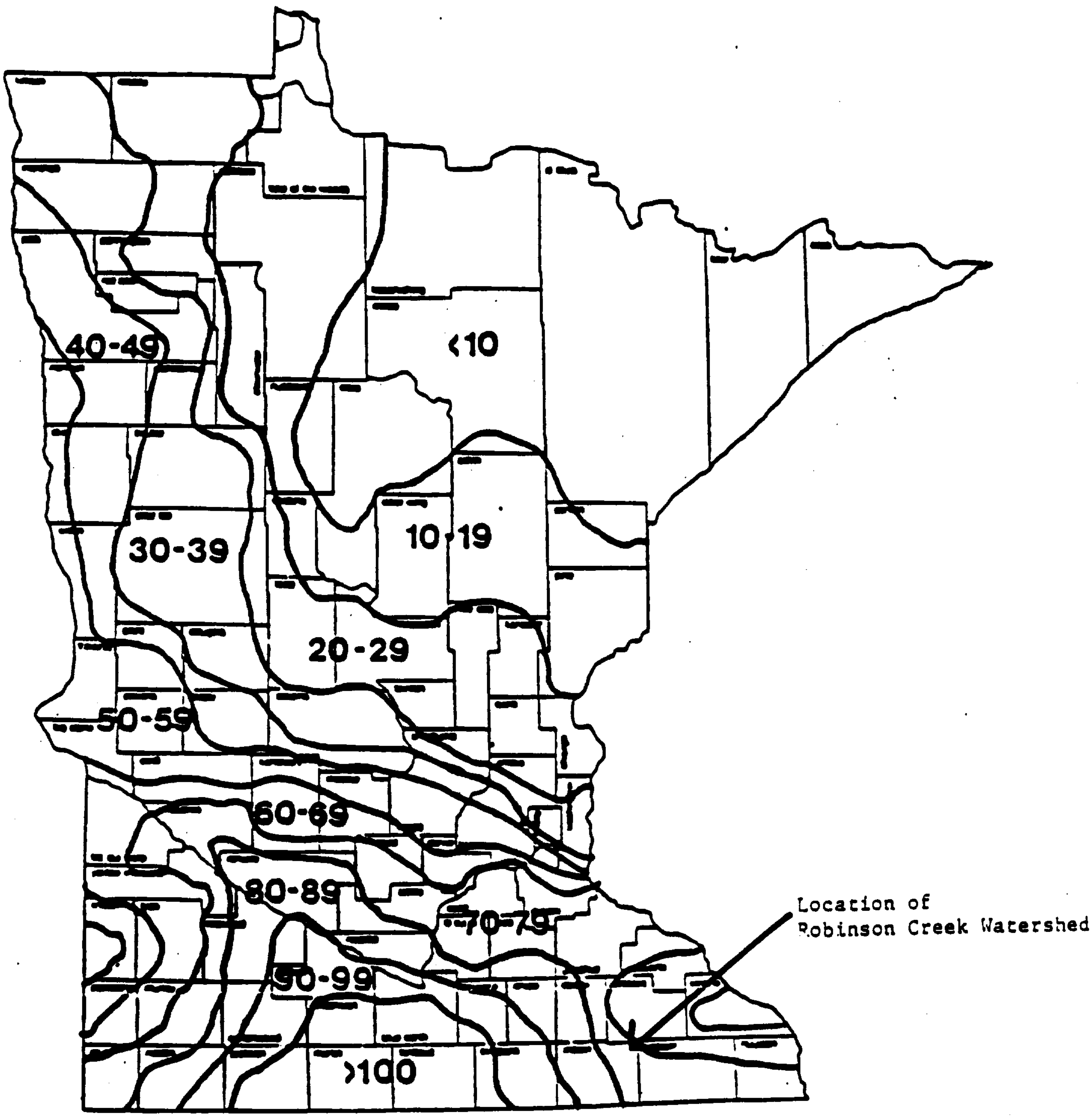
[6]Our measure of reservation price, based on CERs, shows little variation compared to environmental variables; this may be because land productivity is fairly homogeneous in this watershed and/or because variation is obscured by averaging soil type-based CERs over the 40 acre parcels.

Figure 4: 1986 Cash Rental Levels ($per Acre)[1]



[1]Source: Kilgore, 1986

possible crop rotations and tillage combinations. Gross returns per acre is the product of crop yields and crop prices received, averaged for rotations if necessary. Net returns are derived by subtracting direct from gross returns. For purposes of developing reservation prices, we do not subtract indirect costs under the assumption that these would still be incurred. Thus, this is a crop enterprise level calculation, not a whole farm calculation of reservation prices.

The resulting average net revenue values used are $119 for two year corn-soybean rotation with conventional tillage, $114 for the same rotation under no-till, and $49 for pasture with haying and or grazing.

We treated all reservation prices as uninfluenced by productivity losses under a continuation of current cropping practices, despite the likelihood of erosion-induced yield penalties on some parcels. Such penalties occur from loss of both replaceable (major nutrients) and nonreplaceable soil characteristics (primarily depth of favorable rooting zone and water holding capacity). In addition, land retirement is thought to result in a short term increase in yields from accumulated nutrients and organic matter. The extent to which these effects actually influence and individual farmer's decision regarding whether to change land management depends on the susceptibility of the particular soil types to erosion-induced yield losses and on whether farmers incorporate these effects in determining reservation prices.[7]

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[7]We considered including a variable in our policy simulations to reflect a given cell's potential vulnerability productivity loss to erosion. The rationale is that a farmer facing high vulnerability to erosion-induced productivity losses would have a private incentive to change to a more soil-conserving management, thus lowering the reservation price for the cell. We examined the potential productivity losses from loss of nonreplacable soil characteristics using the Productivity Index

Physical variables

Recognizing that water quality may be a function of several physical parameters, we decided that reduction in total sediment (all particle size classes) at the watershed's outlet cell was to be the primary measure of environmental improvement to be modeled (As discussed in Chapter 4, we also simulated reduction in sediment-adsorbed and soluble nitrogen at the outlet cell.) Because we anticipated conducting numerous simulations of alternative policies, we sought a cell parameter that could serve as a proxy for running AGNPS following each policy simulation.[8] In analyzing alternative parameters upon which to base targeting simulations, we were cognizant of tradeoffs between environmental improvement and information costs and soil conservation and downstream effects that would be faced by local watershed managers in actual program implementation.

Our initial list of candidate parameters is as follows:

1) sediment generated within each cell for the assumed storm event under current land use conditions (tons)
2) sediment generated within each cell for the storm event under worst case conditions (tons)

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model developed at University of Minnesota (Pierce et al., 1983). Soil in the RCW vary in their susceptibility to erosion induced productivity losses from nonreplaceable soil characteristics. Some soils in the RCW would begin to suffer yield losses with the first centimeter of soil lost, while others would not for over 100 centimeters. By using bulk density relationships and known erosion rates, centimeters of soil loss can converted to years. Due to time constraints, this procedure was not incorporated in the study.

[8]While AGNPS input parameters were calibrated to be consistent with data on in-stream flow, all of the variables used in our simulations are proxies for monitored on-site or in-stream conditions. The effect of management changes in a set of land parcels to sediment at the watershed outlet could conceivably be measured by actual in-stream changes, simulated changes using event-based or annualized models, or estimates of simulated changes.

3) net sediment yield of each cell to the adjacent downstream cell (calculated as sediment tons generated within the cell plus sediment generated above the cell less sediment deposited within the cell)
4) annual soil loss per cell as calculated by the USLE (tons)
5) annual soil loss per cell from USLE modified by current land management (tons)
6) difference between sediment at the outlet cell under current conditions and when each cell is treated as individually retired (tons)
7) difference between sediment at the outlet cell under worst case conditions and when each cell is treated as individually retired (tons)
8) distance of the cell to the watershed outlet cell measured using the direction of overland flow (meters)
9) distance of the cell to the nearest established channel cell measured the same way (meters)

To shorten the list of candidates for further consideration, we determined their relative performance in reducing sediment at the outlet cell. After deriving values for each of these parameters for each cell, the cells were ranked from highest to lowest (lowest to highest for the distance measures), and the highest (lowest) 5% and 10% of the cells in the watershed were simulated to be retired. The resulting values were a measure of relative performance in reducing outlet sediment. We also determined the parameters' correlation with each other (measured by Spearman rank order correlation) and their relative dispersion (measured by coefficient of variation). Because the distance measures did not perform as well as erosion measures in reducing downstream sediment and are not necessarily easier to obtain, they were eliminated from further consideration; several measures of erosion and outlet sediment yield were examined further.

One concern about using downstream sediment measures is the suspected nonadditivity of sediment reduction effects from retiring groups of cells. That is, the sum of the reductions in outlet sediment from retiring five cells individually is not equal to the reduction when all five are retired at the same time. If the relationship between the two is nonlinear across different numbers of cells retired, OutSedCur could give rankings that are inconsistent.

Our preliminary analyses suggest that this is not a problem. Using the results of the policy simulations discussed later to generate a nonrandom sample of 35 observations, actual sediment values at the outlet (simulated by AGNPS from retiring groups of cells) were regressed on the sum of the OutSedCur values associated with the same groups. The sizes of the groups of cells in the sample ranged from 5% to 40% of the watershed's area. The resulting adjusted R^2 is 0.99, and residuals do not display strong nonlinearities across this range of retirement. These results support the use of OutSedCur as a targeting variable across the range of a watershed's land area likely to be affected by government programs.

With respect to measures of on-site erosion, we examined the commonly used RKLS and RKLSCP values (USLE with and without cropping and practice factors) and the AGNPS-derived variable "within-cell" sediment based on both current management and "worst case" land cover conditions.[9] As expected, "actual" soil loss is less than, but correlated with, "potential soil loss. Table 3 shows the corresponding correlation coefficients. The perfect correlations between "AGNPS potential" and "RKLS" and between

[9] There has been discussion in the conservation community as to whether eligibility for soil conservation programs should be based on actual or potential erosion reduction (so as not to appear to reward poor land stewardship). A similar issue is whether targeting of nonpoint source programs should be based on the effects of current land management practices or on the inherent physical characteristics of the landscape.

Table 3: Simple Correlation Coefficients for Four Measures of Soil Loss

	RKLS	RKLSCP	AGNPS Potential	AGNPS Actual
RKLS	1.00			
RKLSCP	0.65	1.00		
AGNPS Potential	1.00	0.72	1.00	
AGNPS actual	0.65	1.00	0.72	1.00

"AGNPS actual " and "RKLSCP" simply reflect that USLE and AGNPS derived measures of within-cell erosion differ only by a rainfall scale factor.

The land management changes simulated using AGNPS required up to seven input parameters be adjusted in affected cells. These parameters are SCS Curve Number, Cropping Factor, Manning's Roughness Coefficient, Surface Condition Constant, Practice Factor, Fertilizer Level, and Gully Source Level. The values chosen to reflect different management conditions were based on known characteristics of the watershed, recommendations in the AGNPS manual, and professional judgement.

The SCS Curve Number determines direct runoff volume from a given rainfall event. It varies by soil type so that AGNPS cells reflect weighted averages.

The Cover Management (C) Factor expresses the ratio of soil loss from a given land management practice to soil loss from continuous fallow. The closer it is to 1, the greater the soil loss.

Manning's Roughness Coefficient indicates how the texture of a channel affects the speed of channelized flow. As roughness increases, runoff velocity decreases. Different values are used for cells that contain stream channels than those that do not.

The Surface Condition Constant is a value based on land use that adjusts for the effect land use has on channelization of overland runoff. For vegetated land uses, its values ranges from 1.00 (grass waterway) to 0.05 (straight row crop).

The Supporting Practice (P) Factor adjusts the USLE based on the existence of conservation practices such as terracing. Worst case conditions give a P factor of 1.

The fertilizer level in AGNPS has possible integer values of 0-3, reflecting the following Nitrogen and Phosphorus application rates:

Pounds/Acre		AGNPS Input Value
N	P	
0	0	0
50	20	1
100	40	2
200	80	3

The Gully Source Level indicates the tons of sediment resulting from gully erosion. Values are derived from running a separate ephemeral gully erosion model. The values used probably understate changes in erosion from land management changes.

With respect to downstream sediment, we derived two variables based on AGNPS output values at the watershed outlet cell. In addition to the base case land cover conditions (prevailing in 1987 when the aerial photos were taken), AGNPS was run for two reference conditions for the purpose of quantifying the potential impact of changing an individual cell's land management on pollutants at the watershed outlet. In each set of runs, the above input values were changed for each of the 285 cells individually leaving all other cells in base case conditions.

Cells that are classified as being covered by 50% or more forested area were held at their current conditions under our assumption that they would not be modified by any future management changes. In one set of runs, the values were altered to reflect continuous, well-managed permanent pasture to simulate the effects of land retirement and the ten feedlots were eliminated. In the other set of runs, values were changed to reflect maximum erosion conditions, specifically, a corn/soybean rotation with conventional moldboard tillage and a plant canopy corresponding to the seedbed preparation period. This "worst case" reference condition approximates the potential erosion characteristics of the parcels,divorced from current management practices. Input values for each set of runs are shown in Table 4. The values of all nonpoint source pollutants were recorded for the outlet cell.

These two reference condition values enabled derivation of two measures of a cell's relative contribution to downstream sediment reduction by changing land management. The difference in outlet sediment values under base case and retirement conditions is one measure. The difference in outlet sediment between worst case and retirement conditions is the other measure developed.

With this database, we addressed the issue of whether rankings of cells based on different candidate targeting variables would be much different from each other. If two variables give rankings that are similar to each other, but one is less costly to obtain than the other, then a watershed manager might be better off with a less accurate but still acceptable targeting variable.

In particular, there has been policy debate over the extent to which targeting on the basis of on-site erosion is an adequate proxy for reducing downstream effects. Figure 5 shows a scatterplot of the AGNPS derived on-site erosion and off-site sediment measures. The two are clearly correlated. In addition, the high density of cells having a low value of both variables suggest that, after critical cells are enrolled, which

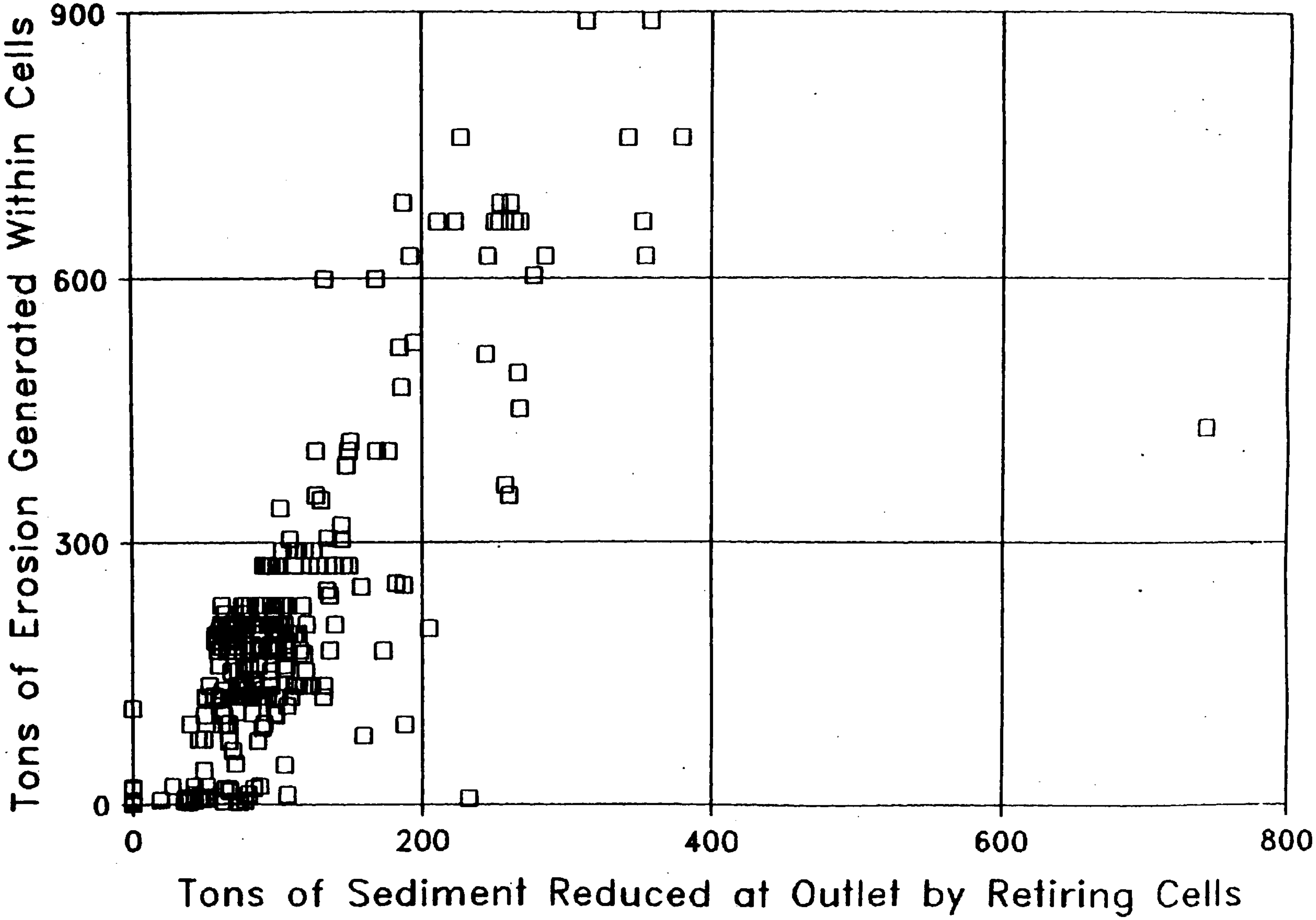
Table 4: AGNPS Parameter Values Used to Simulate Reference Conditions and Intermediate Land Managements

Parameter	Land Management Category				
	Worst Case	Corn\Soy Conv. Till	Corn\Soy No Till	Oats	Retirement
Curve Number	78	78	78	78	55
Mannings Coefficient[1]	0.045	0.100	0.100	0.200	0.3
Cropping Factor	0.74	0.58	0.18	0.12	0.01
Surface Condition	0.05	0.29	0.29	0.29	0.59
Practice Factor	1.00	0.74	0.74	0.74	0.74
Gully Erosion (tons per cell)	191.4	160	160	160	160

[1] A value of 0.048 was for cells having established channels.

Figure 5

Erosion and Sediment Values for Individual Cells in Watershed



variable is chosen for targeting may make little difference in achieving sediment reduction in this watershed. With respect to Spearman's rank order correlations, coefficients between a downstream sediment variable and on-site erosion variable are positive and significant.

Whether the observed correlation between on-site erosion and downstream sediment variables is an artifact of AGNPS or represents real world conditions is key to whether this observation has policy relevance. The finding is consistent with what is known about water erosion mechanics. The starting point for both variables is the modified USLE used by AGNPS. Subsequent algorithms trace the movement and deposition of soil particles. Because AGNPS is relatively insensitive to small topographic features that may cause deposition within a cell, on average, AGNPS tends to overpredict net sediment yield from a cell. This also means that estimated net sediment available to the next cell downstream probably does not vary across cells as much as is actually the case. Models calibrated with smaller cell sizes (not feasible for this research) capture more topographic features that are not incorporated at the 40 acre level (see Panuska and Moore, 1990).

The correlation between AGNPS-derived on-site and off-site variables might thus be biased upward. If so, potential gains from targeting on the basis of the off-site variable could be underestimated. Presumably, further disaggregation of topographic data (for example, ten acre cells) would enable topographic features that affect sediment movement to be modeled. Doing so, however, would require four times as much data to be collected.

The single storm event feature of AGNPS may also have implications for the relative importance of on-site versus off-site targeting. Sensitivity of sediment particle movement to a single storm event is different than to a succession of storms throughout the year. For example, some sediment particles may be moved only to a channel from one storm event, while other particles that reach the outlet cell are already in channels. The variation in the amount of sediment a cell delivers to the outlet cell is different for a single event than for annual rainfall of equivalent magnitude. Thus, the event-based version of AGNPS probably gives different estimates of the potential gains from targeting on the basis of the off-site measure over the on-site measure than would an annualized model.

Intermediate Land Management Restrictions

We also developed measures of erosion and sediment change to be used for intermediate land management changes simulated by "unbundled" cropping rights policy instruments. In addition to land retirement with no economic use, unbundled cropping rights options allowed permanent pasture with haying or grazing and a two-year corn/soybean rotation with a soil-conserving zero tillage system. It was not feasible to change each cell in the AGNPS database to reflect these additional land management options and then run AGNPS each time an unbundled policy was simulated. Consequently, two related procedures were developed to estimate water quality effects associated with land management changes for individual cells.

In one procedure, we used the values from the worst and best case reference conditions derived previously to identify the maximum possible change in outlet sediment from land management change in each cell. Next, appropriate AGNPS input parameter values were developed for specified land management changes. These are shown in Table 4. The input values for 30 randomly selected cells in the watershed were changed to run AGNPS both after changing each individual cell and for all 30 cells. We then calculated the change in sediment for each cell expressed as a percent of the total difference in sediment between worst and best case reference conditions. Finally, these percent changes were averaged and applied the resulting percent change to maximum potential sediment change in all cells in the watershed.

In the other procedure, we identified from air photos those cells in the watershed whose area is covered at least 75% by a single land use. Those land uses for which a sufficiently large number of cells contained only that land use are corn/soybeans/other new crops and hay/grass. Average AGNPS input values for these land uses are shown in Table 5. The above procedure was then followed to derive percent differences between worst and best case sediment values.

The two above procedures were used to derive a set of adjustment factors to pro-rate sediment changes from unbundled cropping rights scenarios that were subsequently simulated. These factors are shown in Table 6.

After obtaining sediment and erosion values for intermediate land management changes, we sought to determine whether intermediate changes from base case conditions behaved similarly to land retirement in terms of the sum of individual cell effects being linearly related to aggregate effects. Using the same 30 randomly selected cells as above, less than a 1% difference was found between sediment reduction at the outlet when all 30 cells were changed from base case conditions and the sum of sediment reductions from changing individual cells.

Table 5: Average AGNPS Parameter Values for Cells Whose Current Land Management is at least 75% in Designated Category

Parameter	Land Management Category		
	Corn\Soy\Row	Grass\Pasture	Average all cells
Curve Number	77	73	77
Mannings Coefficient	0.053	0.064	0.05
Cropping Factor	0.59	0.197	0.58
Surface Condition	0.089	0.254	0.096
Practice Factor	0.75	0.72	0.74
Gully Erosion (tons per cell)	116.7	160.5	159.5

Table 6: Adjustment Factors Used for Estimating Sediment and Erosion Changes in Individual Cells from Specific Land Management Practices

Worst Case	Corn\Soy	Corn\Soy	Hay\Grass	Best Case
Erosion	1.00	0.64	0.10	0.00
Sediment	1.00	0.78	0.30	0.00

Finally, we investigated the correlation between relative soil productivity and on-site erosion. If, as is the conventional wisdom, there is a negative correlation between these, then a policy instrument that seeks to minimize government payments by enrolling low productivity parcels could focus on downstream sediment, rather than erosion, as a targeting variable. However, no such correlation was found.

3.4 Development of Generic Policy Instrument

As stated earlier, the generic policy instrument used in this study consists of take-it-or-leave-it offers of annual payments to landowners in exchange for giving up some or all cropping rights on a given parcel of land. Farmers are assumed to participate according to the simple decision rule of choosing the land management option (including current management) that yields the greatest sum of the government offer and residual net returns (if any) from cropping. Thus, the government's choice variable is the set of nonzero offers made to induce land management changes on parcels of land in the watershed. The value of the offer that we assigned to a given parcel is determined by assumptions made about the government's knowledge of other variables. For example, the government could be assumed to have no information about reservation price except the mean and complete information about the distribution of erosion value. The two pieces of information could then be used to prorate government offers.

We first used spreadsheets and then mathematical programming for simulating alternative policy instruments. Most simulations presented in this report stem from the latter because of its flexibility in simulating alternative program options under different budget constraints, especially when alternative land uses are allowed. While mathematical programming is impractical for widespread use at the local level for targeting purposes, many county SCS and ASCS offices now use computer spreadsheets routinely. The spreadsheet simulations reported in Section 4.4 were based on rank ordering cells by physical variable, reservation price, or the ratio between a physical variable and reservation price. Then rank ordered cells were chosen for retirement based on a budget constraint. This procedure yielded results similar to those obtained by solving a formal mathematical programming problem, as described below. A possible application of this research would be development of a spreadsheet template to facilitate evaluation of targeting options at the county level.

General Math Programming Model

We used integer programming formulations to model the logical conditions inherent in the decision to participate in the program (Williams, 1979), thus altering the management of a parcel of land. Both the PC and mainframe versions of the General Algebraic Modeling System (GAMS) were used to solve the problems (Brook et al., 1988).[10] The government's problem is to minimize sediment at the outlet of watershed subject, to budget and farmers' decision rule constraints. By varying the budget, the relative performance of different targeting options can be evaluated under different budget constraints.

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[10] The mainframe version was required when $C > 2$.

$$\text{Min TOT} = \sum_{i}^{I} \sum_{c}^{C} \text{SedOut}_{ic} * X_{ic} \qquad (1)$$

subject to:

$$\sum_{c}^{C} X_{ic} = 1, \text{ for all } i = 1 \ldots I \qquad (2)$$

$$\sum_{i}^{I} \sum_{c}^{C} \text{OFF}_{ic} * X_{ic} \le \text{BUD} \qquad (3)$$

$$(\text{OFF}_{ic} - \text{RP}_{ic}) * X_{ic} \ge 0 \quad \text{for all } i = 1 \ldots I \text{ and } c = 1 \ldots C \qquad (4)$$

$$\sum_{i}^{I} \sum_{c}^{C} \text{OnEro}_{ic} * X_{ic} = \text{EROS} \qquad (5)$$

where

$0 \le X_{ic} \le 1$

I = 285 cells in watershed

C = 5 land management options

TOT = the sum of each cell's contribution to sediment at the watershed outlet.

SedOut_{ic} = total sediment at the watershed outlet associated with a given cropping/management management option c in cell i.

X_{ic} = decision variable bounded by 0 and 1 that indicates the proportion of a given cell's acreage in each of the possible land cover types. Because of the solution algorithm used by GAMS, X_{ic} takes a value of 0 or 1 for all but one cell.

OFF_{ic} = government offer for management option c in cell i. (For some simulations, we held government offers constant over all cells, while in other simulations, we varied the offers.)

BUD - total dollars available for payments to landowners to induce land management changes.

RP_{ic} - reservation price for management option c in cell i.

$OnEro_{ic}$ - within cell erosion associated with management option c in cell i.

EROS - sum of on-site erosion from all cells in the watershed.

In the sediment minimization problem, equation (1) is the objective function. Equation (2) is a block of equations that constrain the proportions of each cell's acreage in different land management options sum to one. Equation (3) constrains the sum of accepted offers to be no more than available funds for the watershed. Equation (4) is an equation block that defines the farmers' decision rule; it requires that each X_{ic} be zero if the government's offer is less than the farmer's reservation price for a given land management change. Equation (5) is not a constraint but an accounting convenience that shows the effect of solving the sediment minimization problem on on-site erosion.

We also simulated an on-site erosion minimization problem to examine the effects of such policies on downstream sediment. In this version of the model, equation (5) becomes the objective function and (1) becomes the accounting convenience.[11] Finally, a farmer income maximization problem (the sum of residual cropping income and government payments) was simulated subject only to the watershed's budget constraint. For this problem, the

[11]Both of the above specifications have the government choosing between payments of $0 for the land remaining as is or the nonzero offer amount for retirement. While this feature may appear an unnecessary complexity for the simple land retirement problem, it was necessary in analyses in which different payment amounts are possible for different cropping restrictions on a given parcel.

following objective function was used in which REV_{ic} is defined as the net returns realized from using management c on parcel i:

$$\text{Max} \sum_{ic}^{IC} X_{ic} * INC_{ic} \text{ where}$$

$$INC_{ic} = OFF_{ic} + REV_{ic} \text{ when } OFF_{ic} \quad RP_{ic} \text{ and}$$

$$INC_{ic} = REV_{ic} \text{ otherwise}$$

In this problem, earlier equations (2) and (3) were retained as constraints and (1) and (5) as accounting entities.

Chapter 4: Policy Simulation Description and Results

In this chapter, we first describe the various targeted policies simulated, then land use changes resulting from selected policies and their relative performance with respect to cost effectiveness in reducing downstream sediment yield. Finally, we discuss tradeoffs between targeting for one environmental objective on the achievement of others.

4.1. Description of Policy Instruments Simulated

The policy options were developed in order to address the overall objective of evaluating the cost effectiveness of alternative targeting schemes. Within this objective, there are two types of questions that can be posed. The first has to do with which parameters are "better" to use for targeting than others. The second question has to do with how much information the decision maker is assumed to have about these parameters at the time offers are made. The extremes are no information and perfect information. Intermediate possibilities are information about means, ranges, variance, etc. While the number of ways of combining the above parameters and information assumptions is limited only by one's imagination, we explored a few representative targeting options.

As described earlier, the generic type of policy instrument simulated is one in which the government offers take-it-or-leave-it payments to landowners in exchange for making specific land management changes on a parcel by parcel basis. Within this framework, the policy instrument was varied according to the specification of government payment offers, the acquisition of some or all cropping rights, the choice of targeting variable, and the choice of base case land management conditions.

<u>The first policy choice is whether government offers are fixed, matched to reservation prices in each parcel, or pro-rated according to environmental benefits.</u>

There are many ways that government offers can be varied by cell. At one extreme, the decision maker is assumed to have knowledge only of the mean reservation price for various land management restrictions. At the other extreme, we assume the decision maker has perfect information about reservation price. Partial information scenarios, for example, whether a given cell's reservation price lies above or below the mean for the watershed, were not examined here.

We developed a set of government offers based on the concept of tying payment levels to the social benefits that accrue from land management changes. In this variation, we assumed that the government has information only about the mean net returns from typical land management practices, such as the two year corn-soybean rotation, and about on-site erosion levels. These assumptions are roughly consistent with the information currently available to local CRP administrators.

Specifically, we scaled the watershed average reservation price for land retirement ($119/acre) by the square root of the ratio of individual cell erosion value to mean erosion value. (We used square roots to keep the adjustment factor within reasonable bounds as the ratio otherwise varies by more than a factor of ten) In addition, we capped the government offers at $150/acre, representing a government decision about the maximum possible reservation price for the watershed.

The second policy choice considers whether all cropping rights are acquired (total retirement) or only some cropping rights are acquired (allowing an economic return).

Cropping rights are assumed to be bundled or unbundled. In the bundled simulations, land retirement is the only land management decision allowed. In unbundled simulations, we added two management alternatives to the decision:

a) Permanent pasture in which haying and/or grazing is allowed. The derivation of each cell's parameter values are discussed earlier. Water quality implications are less than for complete land retirement, but reservation prices are also less since an economic return is allowed. We assume that the return is the average of net returns from haying and grazing in the area. (Net returns for the two activities are different because both gross returns and costs are different.)

b) A two year corn-soybean rotation in which a more soil conserving tillage system is practiced than is currently prevalent in the RCW. While compliance monitoring may be more difficult than for cropping alternatives, such a system is important to model because it offers significant water quality improvements over current practices and may be more attractive to farmers than the other options.

For each potential change from current land management practices, there is an associated reservation price that we define as the minimum annual payment a landowner would require to induce making the change on a specific parcel.

When all cropping rights are acquired, the government cannot select the most cost effective cropping restriction within each cell. The more a policy instrument allows cropping rights to be unbundled, the more cost effectiveness can be attained within as well as across cells.

While adding two alternatives enabled us to demonstrate at minimal computing cost the changes in simulation results from unbundlings, there are several other ways in which unbundling could be simulated:

a) Allow a greater range of specific land management options

b) Acquire whatever unspecified cropping rights are necessary to achieve a desired level of environmental protection (for example, a soil loss no greater than "T") on each parcel or for the watershed as a whole.

c) Acquire specific rights such as row cropping or all rights except that to grow permanent pasture.

<u>In the third policy choice, cells are prioritized for management change according to on-site erosion or off-site sediment.</u>

This choice determines whether the AGNPS-derived variable for on-site erosion or off-site sediment is used in the objective function of the optimization problem. For on-site measures of erosion, we assumed perfect knowledge for each cell of the within-cell erosion for a given storm event, an AGNPS output variable. An alternative would be an annualized soil loss measure.

For the off-site measure, we used the off-site sediment variable created by running AGNPS for each cell. An alternative to this sediment variable used would be some proxy that is highly correlated with it.

The fourth choice is whether government offers and erosion/sediment reduction are based on current land management or worst potential land management.

Under the current land management assumption, we used land use data taken from SCS 1987 air photos of the watershed. When acquisition of partial cropping rights were assumed possible, sediment savings and reservation prices remain positive only on those cells not already in pasture. Alternatively, when we assumed the base case to be corn/soybeans under conventional tillage, government offers were based on reservation prices associated with growing corn and soybeans under conventional tillage. Potential sediment savings were, of course, greater than when current land uses were assumed to be retained without government intervention.

The two data sets are based on two alternative assumptions. One is that current land management (at least as of the date in which watershed data was collected) represents profit-maximizing conditions for landowners with no potential for future land management changes absent government intervention. Thus, payment offers made to landowners need only reflect the opportunity costs of moving from current management practices to ones that have lower net returns. The other assumption is that any parcel of land has the potential for being converted to conventionally tilled corn-soybean rotation; consequently, government offers must reflect the reservation price of moving from this management to one of the others. When the latter assumption was used, we also assumed that sediment and erosion changes also reflect conventionally tilled corn/soybean rotation as the initial condition in all cells.

Of the 24 possible permutations of the above choices, we have examined the set that is listed below. Each option is designated by a composite acronym made up of the acronyms associated with its respective features.

Government Offers

Fixed Offer: FX
Match Reservation Price: RP
Offer Based on Erosion Ratio: RAT

Cropping Rights Acquired

Retirement Only Allowed: RET
Unbundled Cropping Rights Possible: UN

Physical Variable for Targeting Priority

On-Site Erosion: ON
Off-Site Sediment: OFF

Base Case Land Management Assumption

Current Conditions: CC
Worst Case Conditions: WC

We analyzed the following set:

WC-UN-FX-OFF
WC-UN-RP-OFF
WC-RET-FX-OFF
WC-RET-RP-OFF
WC-RET-FX-ON
WC-RET-RP-ON
WC-UN-FX-ON
WC-UN-FIX-OFF
WC-UN-RP-ON

CG-RET-FX-ON
CC-RET-FX-OFF
CC-RET-RAT-ON
CC-UN-RP-OFF
CC-UN-RP-ON
CC-RET-RP-ON
CC-RET-RP-OFF

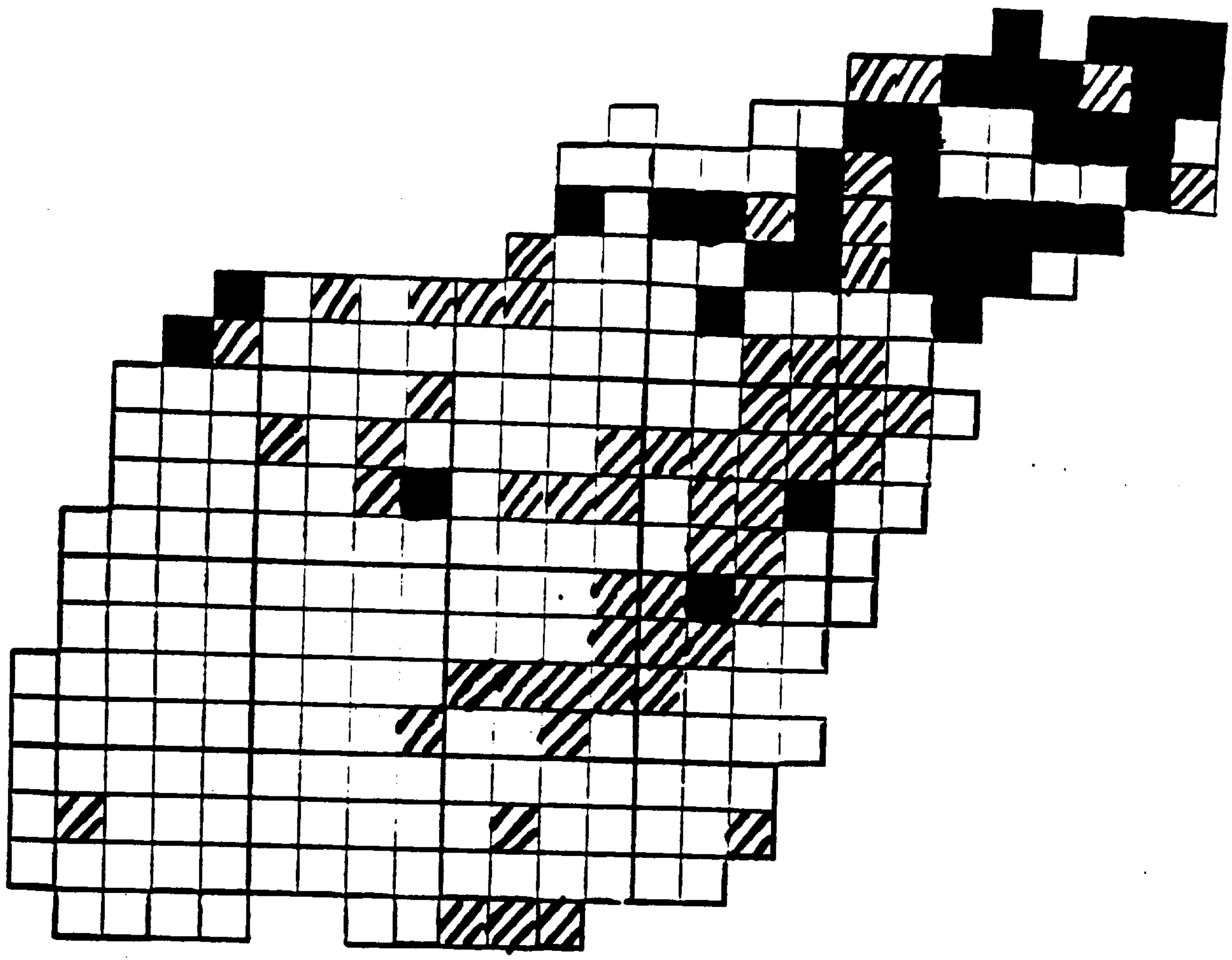
In addition, we simulated four options that changed the optimization problem from one in which the government minimizes sediment to one in which landowners maximize income (defined as the sum of cropping revenue and government payments) still subject to the government's budget constraint. These "untargeted" instruments served as a basis for comparison with various targeted instruments. Two are based on fixed offers and worst case base case conditions. Their only difference is that one allows retirement only while the other unbundles cropping rights. Because there is no targeting based on physical variables, their acronyms are WC-RET-FX-NO and WC-UN-FX-NO. The other two are based on current land management and land retirement. Their acronyms are CC-RET-FX-NO and CC-RET-RAT-NO.

4.2. Simulated Land Use Changes

Simulation results can be presented spatially, that is, by showing the pattern of cells in different land management practices resulting from optimizing a given policy instrument at a given budget level. This is exemplified in Figures 6 and 7 that show, respectively, the pattern resulting from simulating WC-UN-FX-OFF and CC-UN-FX-OFF, both at a $160,000 budget. In both figures, land retirement tends to be concentrated near the watershed outlet where there is relatively little opportunity for sediment deposition to occur before it reaches the outlet cell. In Figure 6, corn/soybean no-till acreage is concentrated in the middle of the watershed and tends to be near stream channels. The remainder of the cells are unchanged. Figure 7 illustrates the ability of the same budget outlay to affect almost all the cells when current conditions are used as the base.

Simulation results can also be displayed to show how total acreage in different management options changes as the budget increases. Figures 8 and 9 depict acreage resulting WC-UN-FX-OFF and CC-UN-FX-OFF, respectively, for the full range of budgets. As shown, increasing budgets result in a shift in total watershed acreage from no-till to the more expensive permanent pasture/no economic return option. Increasing the budget, however, does not necessarily result in greater total acreage being

Figure 6: Land Management Pattern Resulting from Simulation of WC-UN-FX- at $160,000 Budget



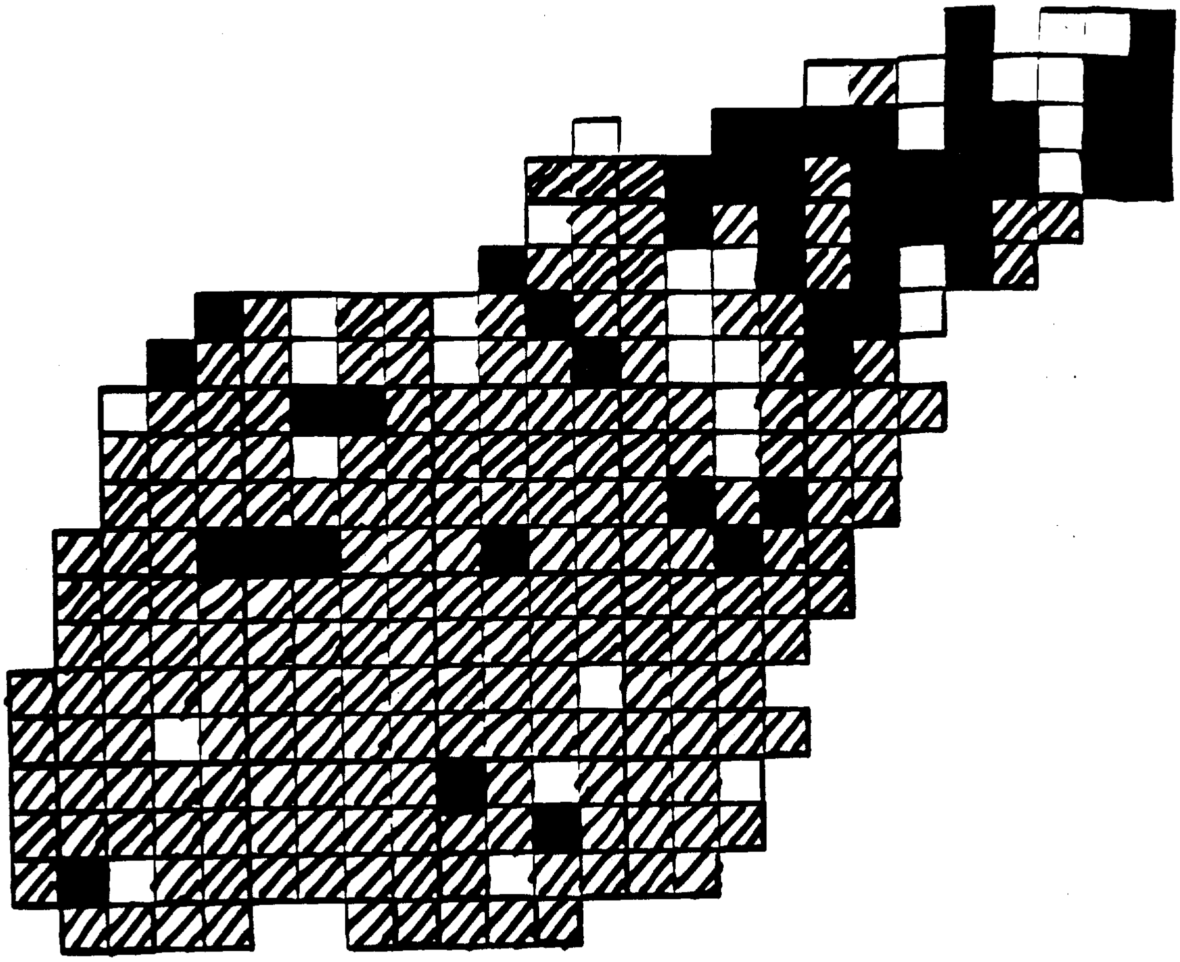
KEY:

CONVENTIONAL TILL

NO TILL

PERMANENT PASTURE

Figure 7: Land Management Pattern Resulting from Simulation of CC-UN-FX-OFF at $160,000



KEY:

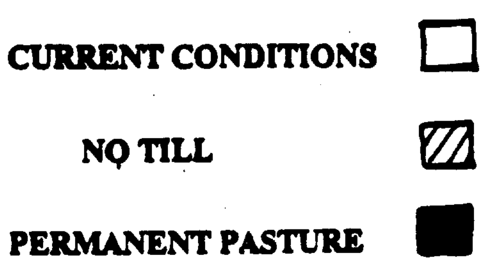


Figure 8

Management Changes Under Increasing Budgets

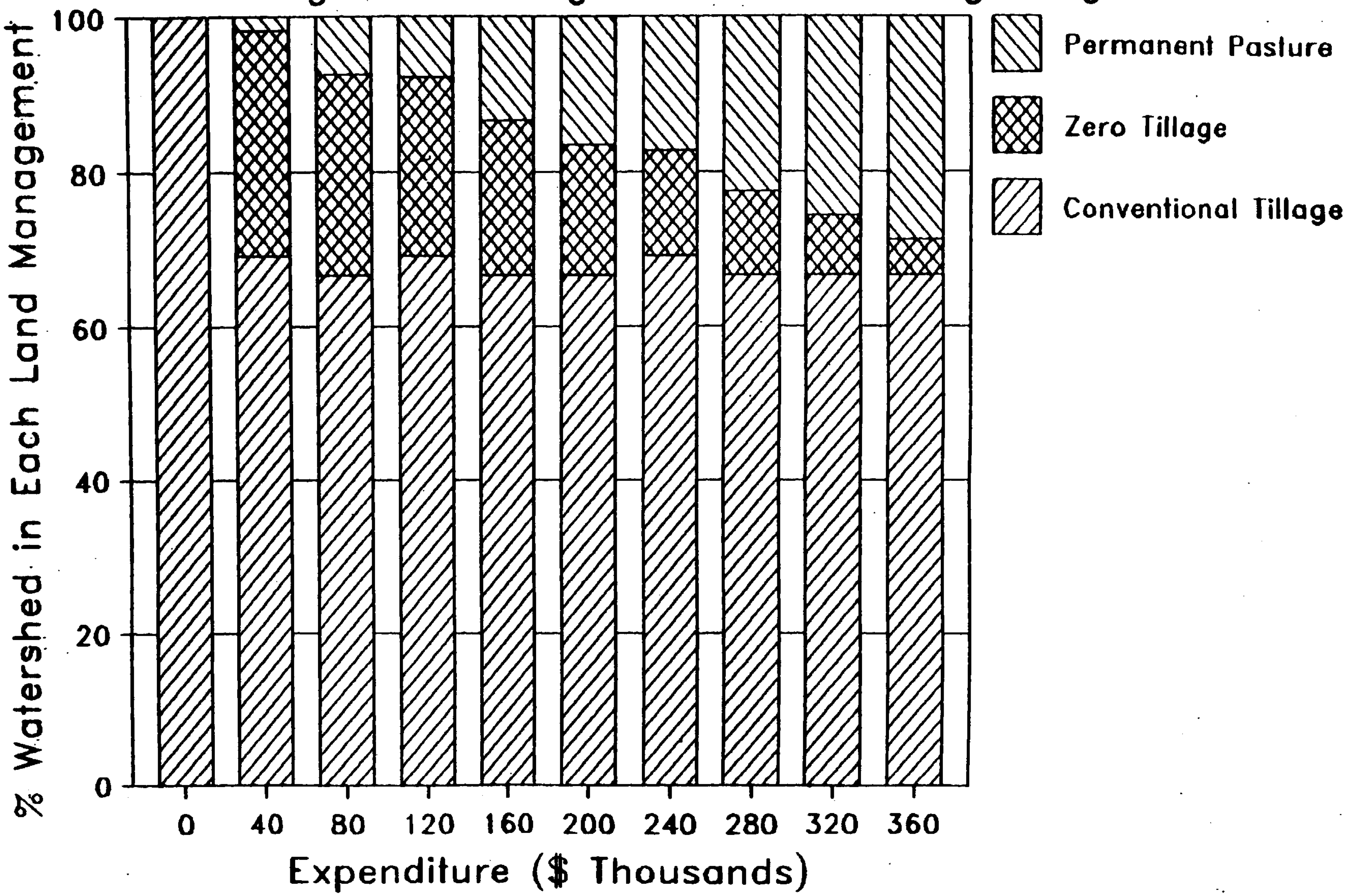
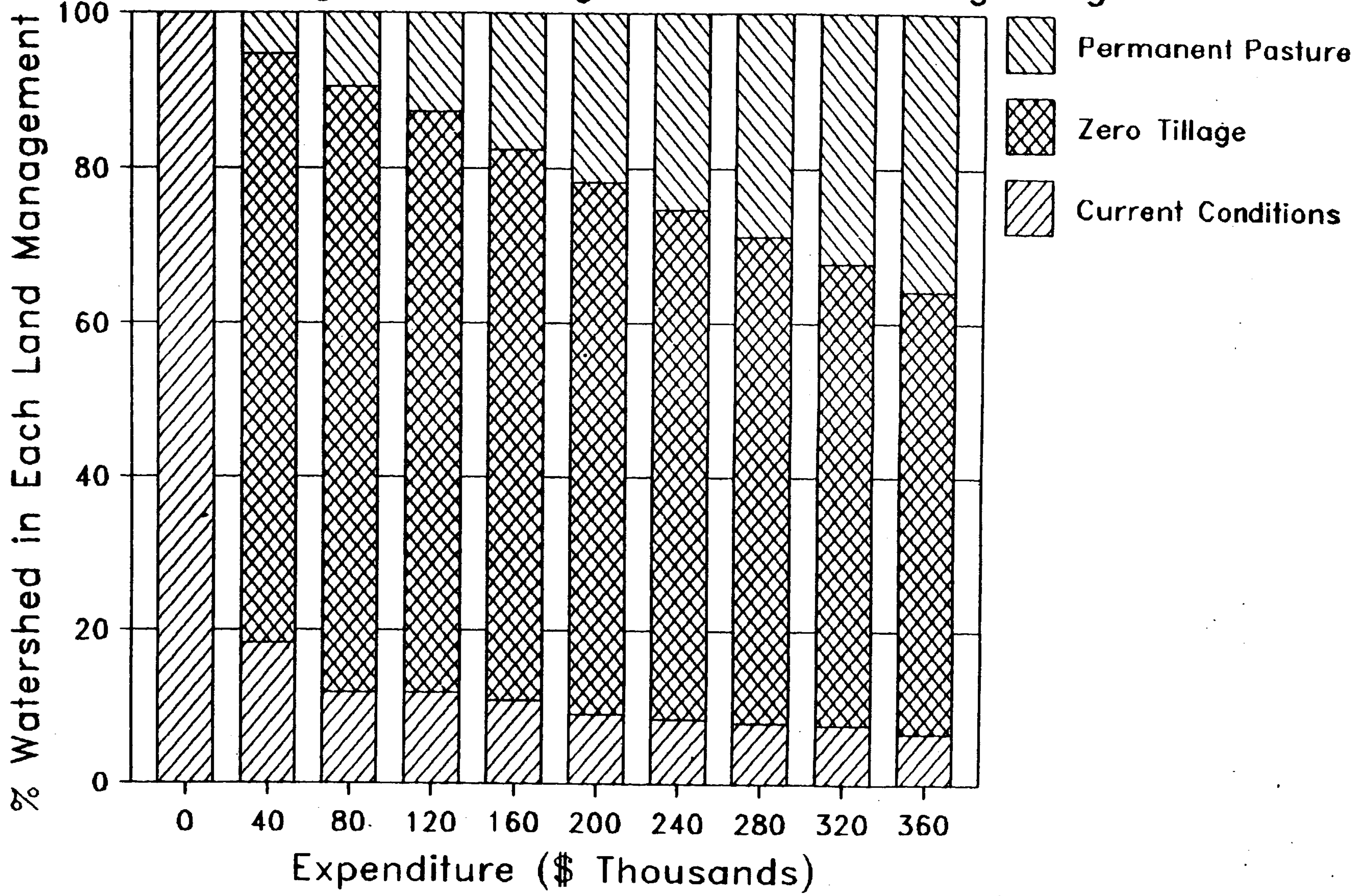


Figure 9

Management Changes Under Increasing Budgets



affected. The total acreage of land whose management changes remains about the same over all positive budgets. For these unbundled options, management restrictions intensify, rather than extensify. However, when retirement is the only management change allowed, total acreage retired increases steadily as the budget increases.

While not apparent from subsequent results, "pasture with haying/grazing allowed" management occurred only in two cells for any of the policy options. For a land management options to be selected by the optimizing routine in a given cell, the percent sediment reduction per dollar of government offer must be greater than for other management options and government offers must exceed reservation prices for that cell. The pasture with hay/grazing management option fulfilled both criteria only twice and thus contributed little to the cost effectiveness of unbundled policy options.

4.3 Cost Effectiveness Results

The remainder of this chapter discusses simulation results presented as cost effectiveness curves. We compare subsets of the above policy instruments in several graphs to focus on specific questions. The horizontal axis of each graph represents the nine budget constraints used in the simulations, ranging from $40,000 to $360,000. At the $119/acre average reservation price for full retirement, this range of budget constraints would retire roughly 2% to 22% of the watershed's acreage.

The vertical axis of each graph is the percent reduction in sediment at the watershed outlet. Program option cost effectiveness is then the percent reduction for each budget expenditure.

The next several graphs contain results from simulations in which base case conditions are assumed to reflect worst potential erosion. Figure 10 compares five retirement only options.[12] WC-RET-FX-NO (incorporating no targeting), performs the worst, with respect to cost effectiveness and WC-RET-RP-OFF performs the best (targeting based on off-site sediment and matching reservation prices), as expected. Not anticipated was the sensitivity of other options to the budget constraint. For budgets greater than $160,000, matching reservation prices appears more cost effective than targeting on the basis of off-site sediment. This is discussed further below.

Figure 11 compares five options that allow unbundling into the four land management practices. As in Figure 10, the option that targets on off-site sediment and matches reservation prices performs the best and the option with no targeting and making fixed offers performs the worst. Here, however, the option that matches reservation price and targets on site erosion outperforms the option that targets on off-site sediment but offers uniform payments over the full range of budget constraints.

Figure 12 highlights the relative cost effectiveness of targeting on the basis of off-site sediment, unbundling cropping rights, and matching reservation prices. Unbundled rights/fixed offer options outperform retirement/matched reservation price options only in the lower half of the budget range. To interpret this result, remember that unbundling cropping rights allows the variation in sediment reduction from intermediate

[12]Results are somewhat different than in the retirement options analyzed earlier in the study because, here, reservation prices have a different base than before. As before, whether it is more advantageous to incorporate information on reservation prices or on downstream sediment contributions of cells depends on how much money the manager has to spend.

Figure 10

Cost Effectiveness of Land Retirement Options

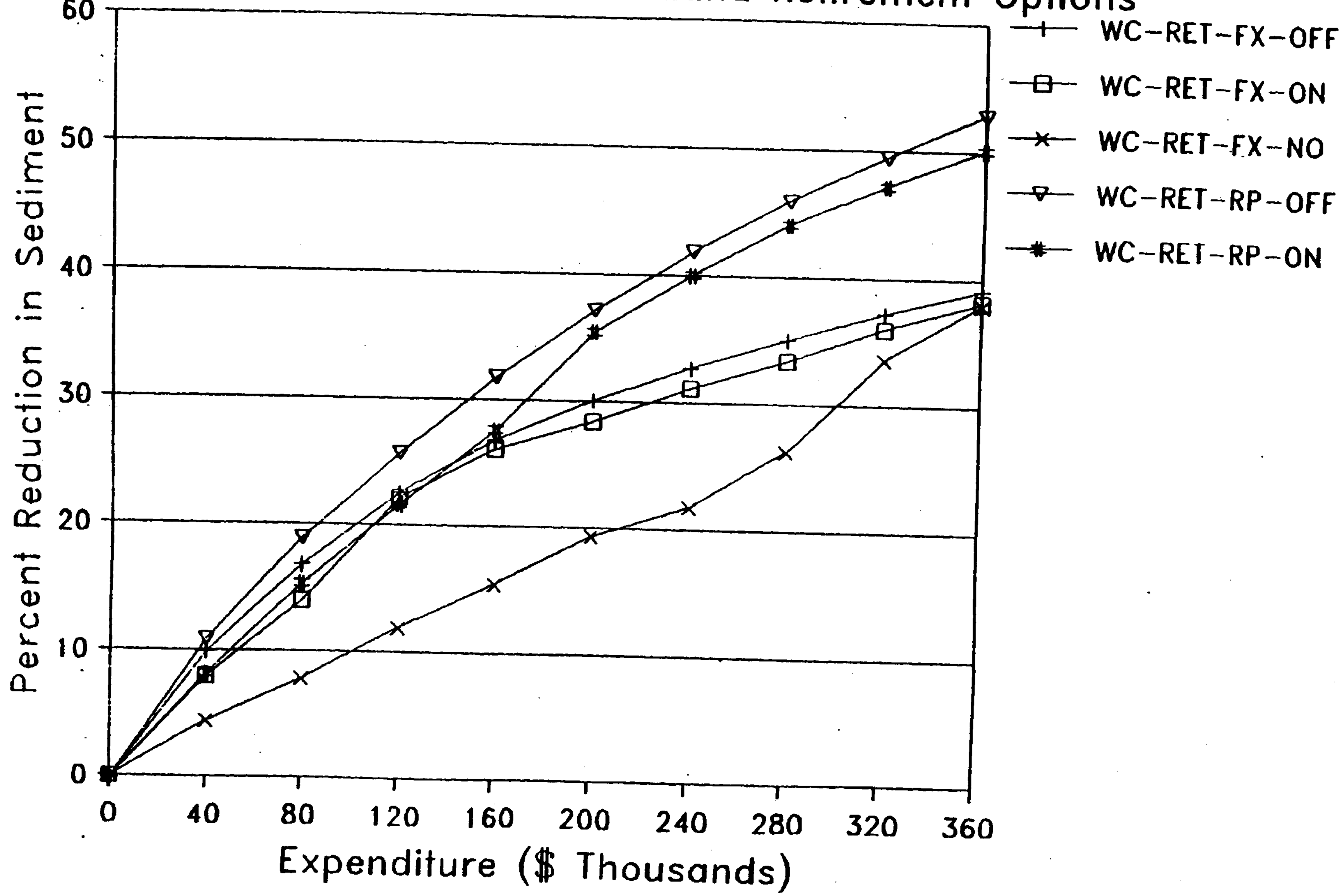


Figure 11

Cost Effectiveness of Unbundled Options

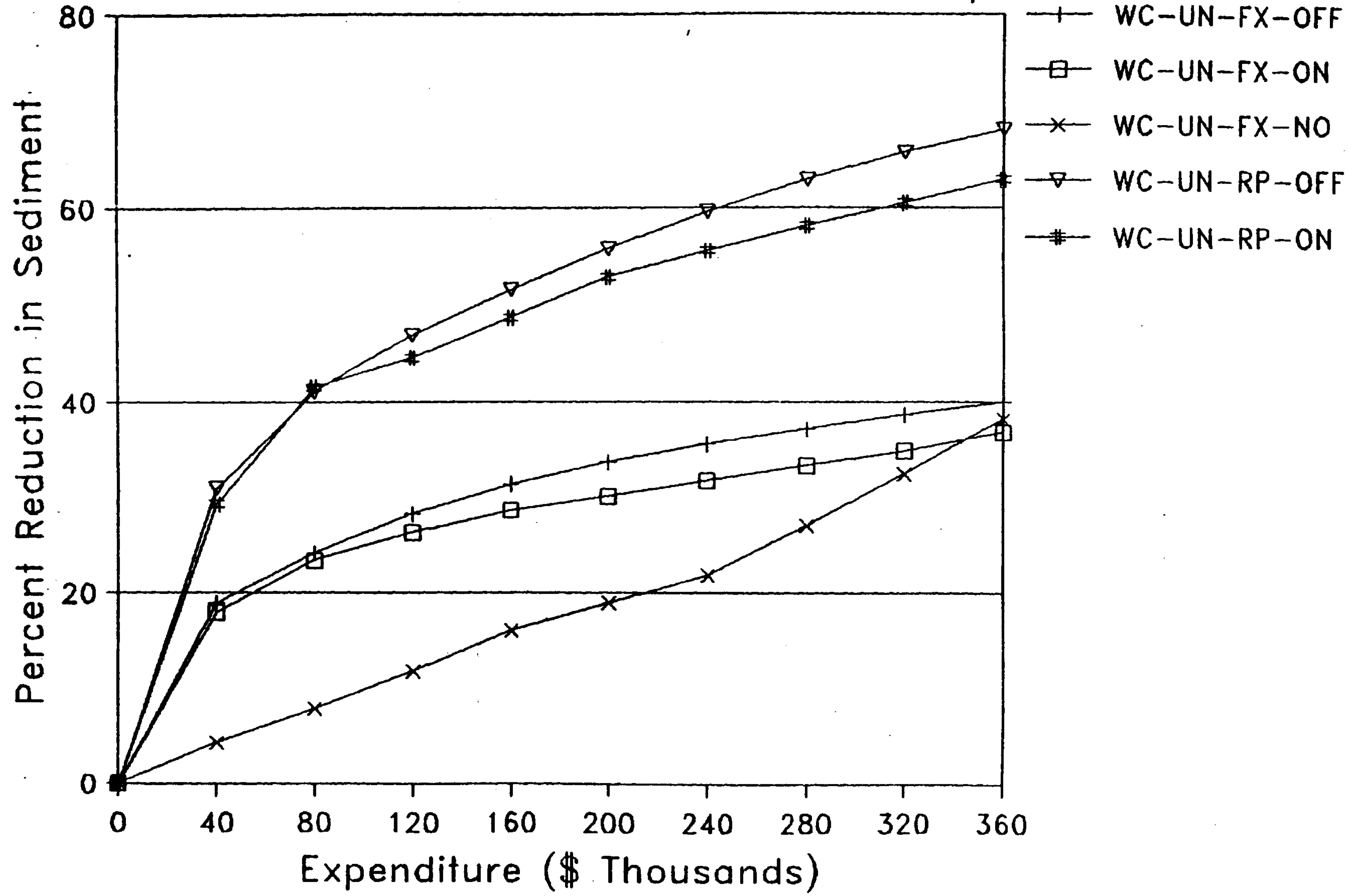
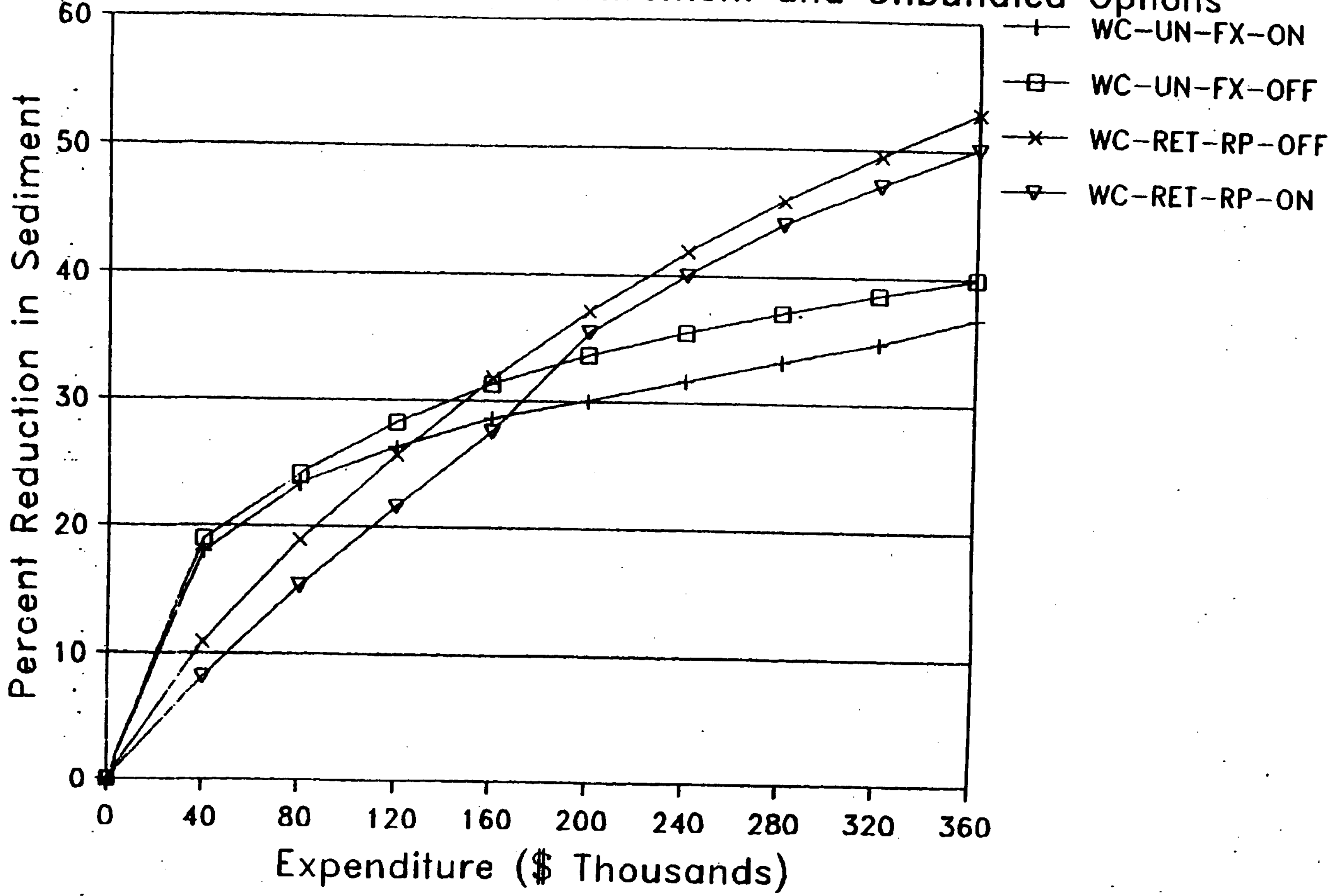


Figure 12

Cost Effectiveness of Retirement and Unbundled Options



management restrictions among individual cells to enhance cost effectiveness. Since this variation is limited at the extreme by the variation in sediment reduction from total retirement across cells, cost effectiveness gains are similarly constrained as more and more cells' management is changed. The distribution of sediment reduction values is such that most cost effectiveness gains are exhausted after a small percentage of the watershed's land area is affected. In contrast, the distribution of reservation price values is such that matching reservation prices continues to yield cost effectiveness gains over uniform offers for the full budget range. (For further discussion on the distribution of these variables, see Chapter 3.)

The next three figures (13-15) present similar comparisons to those above but take current land management conditions as the base case. Figure 13 compares five retirement only options. In contrast to the comparison of the same options when the base case is "worst management," here the ordering of options is constant over the entire budget range. That is, targeting off-site sediment with fixed offers never outperforms targeting on-site erosion with variable offers. We speculate that, while using current conditions introduces additional variability into both sediment reduction and reservation prices across cells, the effect on cost effectiveness is dominated by increased reservation price variation.

Figure 14 compares the cost effectiveness of unbundling cropping rights with that of targeting on the basis of off-site sediment when all options match reservation prices. Here, while unbundling dominates targeting off-site sediment, cost effectiveness curves for CC-UN-RP-ON and CC-RET-RP-OFF appear to be converging at high budget levels.

Figure 13

Cost Effectiveness of Current Conditions/Retirement Options

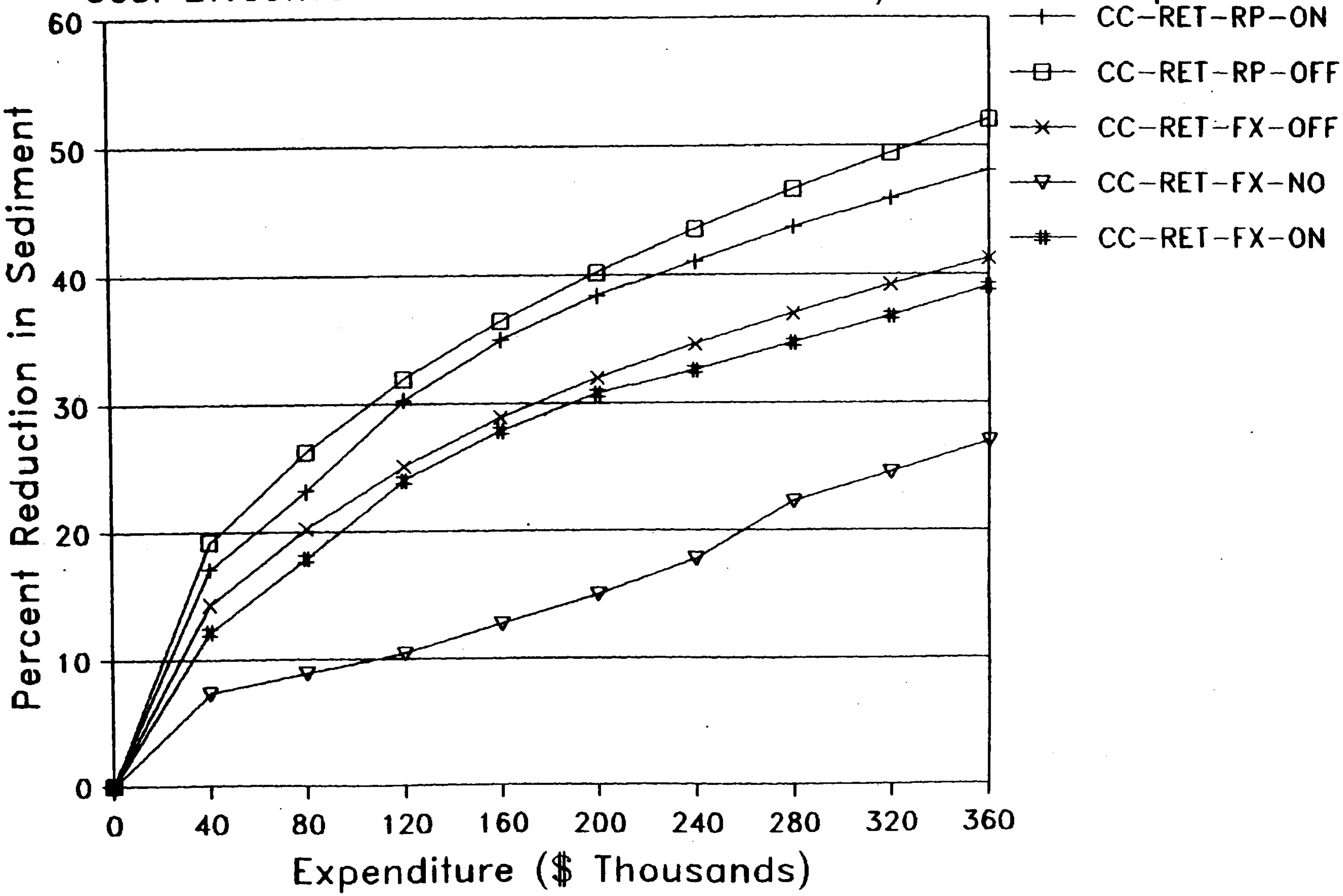
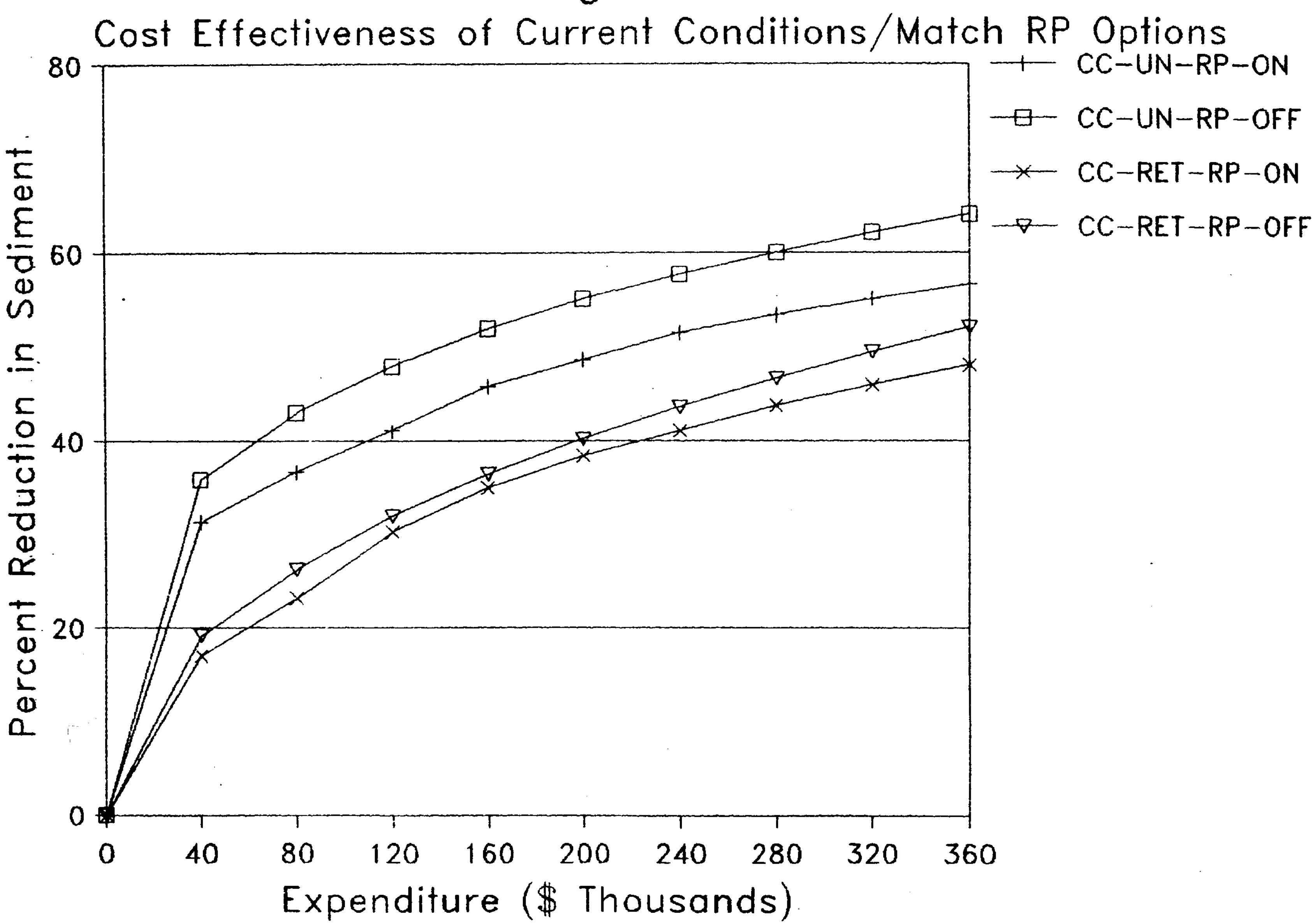


Figure 14



Cost Effectiveness of Current Conditions/Match RP Options
Percent Reduction in Sediment
0
20
40
60
80
0
40
80
120
160
200
240
280
320
360
Expenditure ($ Thousands)
CC-UN-RP-ON
CC-UN-RP-OFF
CC-RET-RP-ON
CC-RET-RP-OFF

Figure 15

Cost Effectiveness of Current Conditions/Retirement Options

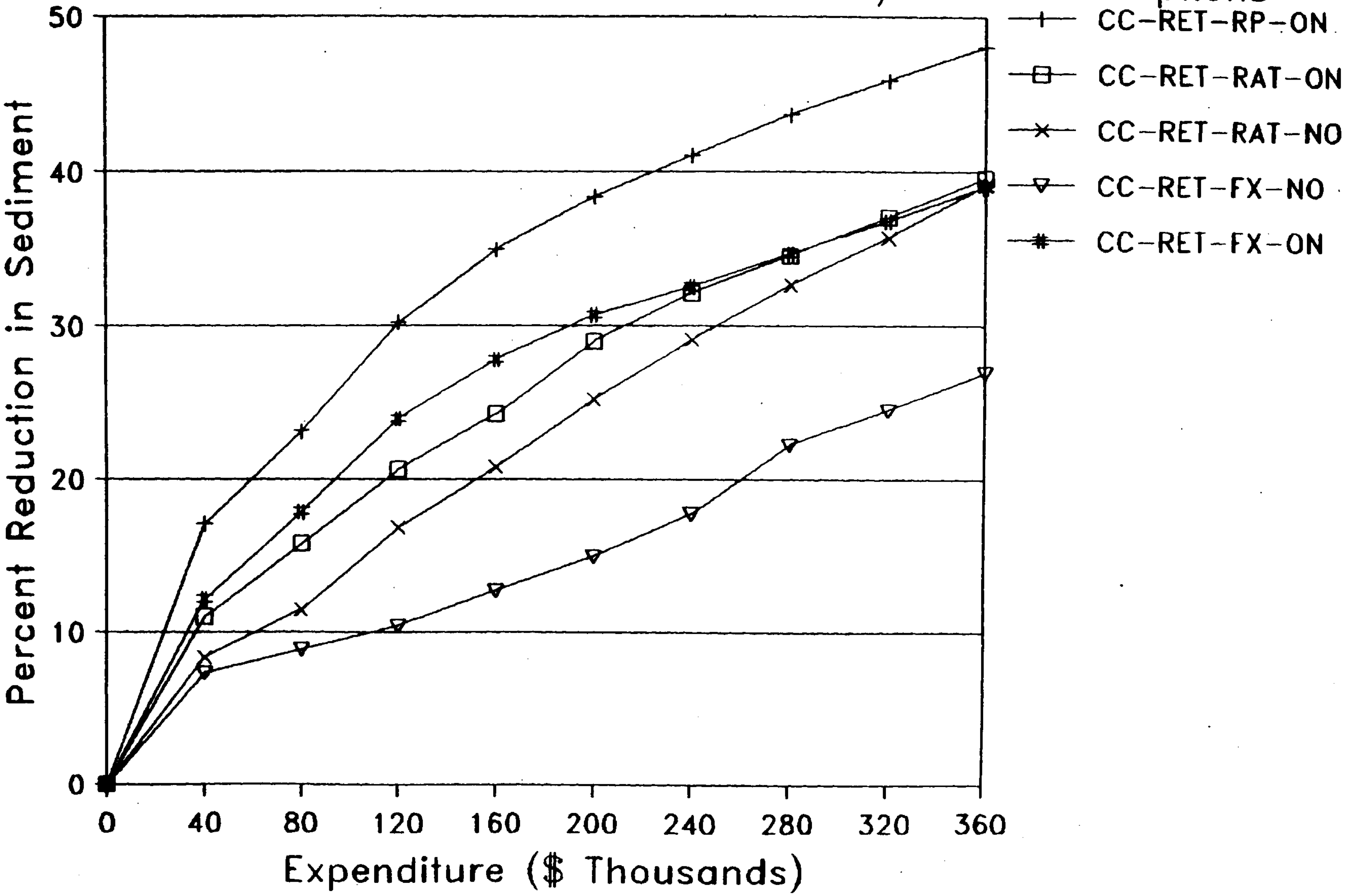


Figure 15 compares five options reflecting three types of government offers--fixed offers, matched reservation prices, and offers based on the erosion ratio described above. All options are for retirement only. The ratio offer scheme results in a mixed cost effectiveness performance. CC-RET-RAT-NO outperforms CC-RET-FX-NO over the entire budget range. Thus, when farmers are simulated to maximize income (rather than the government minimizing sediment), the ratio-based offers simulate the effect of targeting on physical variables. However, CC-RET-RAT-ON is outperformed by CC-RET-FX-ON in the lower half of the budget range and the two converge for the remainder. When the government targets on sediment, cost effectiveness then depends on whether government offers exceed reservation prices. This is the case for 146 (out of 285) cells when offers are fixed and only 125 cells when the offer is ratio-based. These results suggest that ratio offer schemes offer potential cost effectiveness gains over uniform offers, especially when targeting on physical variables is otherwise completely absent. However, the number of cells in which underpayment and overpayment occurs (relative to private reservation prices) for a given ratio offer scheme could still exceed that from a fixed offer option.

4.4. Trade-offs Among Environmental Objectives

In an actual land management program, it is likely that there will be multiple environmental objectives, such as soil conservation and reduction in downstream sediment and nutrient loadings. The analytical framework used here enables identification of trade-offs among such objectives when comparing alternative policy options.

As expected, targeting on the basis of outlet cell sediment reduction does not reduce on-site erosion as much as does targeting on the basis of on-site erosion, and vice versa. The magnitude of this trade-off varies according to the particular policy instruments being compared and to the size of the budget.

For a few options using the spreadsheet approach, we also examined the effects of targeting land retirement for sediment or erosion on nutrient loadings at the outlet cell. Nutrient loadings may change because of reduced erosion and runoff as well as fertilizer not being applied to retired parcels (which was simulated by altering the AGNPS input parameter for fertilizer). The relative performance of the different policy options in reducing sediment-attached nitrogen is the same as for sediment itself. For soluble nitrogen, no clear pattern emerges. In some cases, targeting on the basis of sediment outperforms erosion-based targeting, but in other cases, the opposite is true. Furthermore, cost effectiveness does not consistently decline as a greater percentage of the watershed is retired. Reduction in soluble nitrogen (measured in pounds per acre) is thought to be largely a function of reduction in runoff volume so neither erosion nor sediment are necessarily appropriate ranking variables. This may explain why the performance of the different policy options is not clearly differentiated. However, it is clear that if soluble nutrients are a significant concern in a watershed, the parcels of land that are "best" to treat for sediment and sediment-attached nutrient reduction may be very different than those for soluble nutrients.

Chapter 5: Discussion, Policy Implications, Caveats, and Future Research Agenda

5.1. Summary

Cost effectiveness tends to increase as policy instruments incorporate more information about heterogeneous characteristics in the watershed. Policy instruments that differentiate parcels on the basis of either an environmental variable or reservation prices outperform those that do neither. Options that incorporate information about both physical characteristics (sediment at the outlet or on-site erosion) and economic characteristics (reservation price) of individual cells outperform options incorporating just one or the other type of information.[13]

The efficiency gains afforded by options using a cell's contribution to outlet sediment as the targeting variable (as opposed to on-site erosion) tend to decline as increasing proportions of the watershed are retired. There are relatively few cells with extremely high outlet sediment values that don't also have high erosion values. Once these critical cells have been brought into the program, incremental sediment reduction does not vary much regardless of whether targeting is based on on-site erosion or off-site sediment variables.

The relative cost effectiveness gains from matching reservation prices versus targeting off-site sediment appear sensitive to the size of the budget. For relatively large budgets, using individual reservation prices to target land retirements has as large a cost effectiveness impact as does

[13] All of the targeted policy options simulated in this report incorporate more information than does the current CRP whose land eligibility standard allows all parcels meeting that standard to be retired simultaneously.

estimating and employing downstream sediment contribution, rather than on-site erosion. This is because the frequency distribution of reservation price is such that the marginal cost of enrollment is relatively constant over the full range of budgets considered, while marginal benefits approaches zero at high budget levels. Varying government offers on the basis of the relative environmental benefits of land management changes across parcels outperforms fixed offers only under certain conditions.

The marginal cost effectiveness of policy options tends to (but does not always) decline for a given option as the budget constraint is relaxed, allowing more land to be enrolled. Marginal gains from targeting diminish because the difference in environmental damages among many cells is very small.

Unbundling cropping rights offers cost effectiveness gains over retirement only options; however, the effect of unbundling can be dominated by other effects, especially at higher budget levels. Not all allowed land management options are necessarily expressed in the realization of an unbundled policy instrument.

Cost effectiveness gains from targeting are sensitive to assumptions regarding future land management in the absence of inducements to change management. If we assume that current land management practices will prevail in the future (absent any of the simulated policy instruments) regardless of changes in relative input and output prices, then government offers can be pegged to reservation prices based on current management practices. Alternatively, if we assume that future price (and commodity program) conditions potentially induce each parcel to be managed in the most erosive manner currently practiced on some parcels, then both payment offers and resulting sediment reduction will necessarily be higher. In the study watershed, the net effect of spreading the budget over more parcels (with a concomitment smaller percent sediment reduction per parcel) is greater cost effectiveness. Some cells with high environmental sensitivity are currently being managed in ways such that erosion is kept low, so these cells are not usually targeted in the schemes examined here.

Finally, there are inherent trade-offs in seeking more than one conservation objective, because seeking high priority cells for one objective (soil productivity, say) are not necessarily high priority cells for another (downstream sediment yield). Such trade-offs appear to be smaller when the proportion of the watershed's area brought into a program is large and when the correlation is high between the targeted objective and other objectives of concern.

5.2 Discussion

Results from this study strongly support the conclusion that micro-targeting offers potential cost effectiveness gains. As discussed in Chapter 3, however, this is not the same as concluding that the benefits of micro-targeting are worth its costs. While the above targeting schemes could presumably be arrayed according to their data collection and other costs, a rigorous benefit/cost analysis of each scheme is beyond the scope of this study. However, the magnitude of savings under some options is sufficiently large to suggest favorable benefit/cost results, given certain strong assumptions. The first assumption is that the simulated differences in percent sediment reduction reflect actual differences that would be observed under the various schemes. The second assumption is that such actual differences translate into absolute sediment reductions that are meaningful in monetized or unmonetized social benefits. The third assumption is that savings in budget outlays achieved ex post can be sufficiently predicted ex ante to enable appropriate targeting choices to be made.

Given these assumptions, one can compare the required budget outlays to achieve some level of sediment reduction under the various schemes. Depending on the sediment reduction goal, budget constraint and policy instruments being compared, annual savings in government outlays from micro-targeting are as high as $200,000 within the study watershed. These savings are roughly equivalent to the amount required to retire about 15% of the watershed's cropland. The front end costs of targeting would then have to be compared with the discounted present value of this stream of benefits over the period of enrollment of a given land parcel. Applied to a CRP-like program (with annual payments), a portion of these savings would be realized each year of the contract period. For easement programs with up-front payments, all savings would be realized in the first year. (Our study examines annual savings, not present values; however, qualitative results would be the same.) In either case, the present value of savings in outlays may exceed the one time costs of data acquisition for certain of the targeting options. Micro-targeting appears worthwhile in the study watershed for a wide range of discount rates, budgets, and policy options.

From our experience, however, data acquisition and analysis costs of some targeting schemes appear sufficiently large that net present values cannot be assumed positive for all targeting options in all watersheds. While our results do not indicate firm decision rules for determining the relative importance of alternative variables upon which to differentiate land parcels in a watershed, they do suggest some general guidelines for allocating a limited budget between targeting activities (such as data collection and analysis) and actual outlays to landowners.

First, existing (sunk cost) data could be used to estimate ex ante how heterogeneous the watershed is with respect to land management practices, topography, and soils (both productivity and erodibility characteristics). The greater the heterogeneity of some characteristic, the greater the potential cost effectiveness gains from targeting based on that characteristic and the more money it is worth spending to obtain data needed to implement a targeted scheme.

Second, the total budget available could be compared to the watershed's area. If budget constraints limit estimated total sediment reduction to a small fraction of the total potential reduction, allocating resources to targeting activities may leave too little money for cropping rights acquisition. At the other extreme, if the budget is sufficiently unconstrained to acquire cropping rights for most of the watershed's land area, targeting on the basis of physical variables will yield little cost effectiveness gains (although matching reservation prices might still be effective).

Third, if two watersheds have comparable outlet sediment yields under current conditions, their acreage could be compared. A small watershed whose physical or economic variables exhibit large dispersion may be a better candidate than a large watershed whose variables exhibit small dispersion. For the same gain in cost effectiveness, fewer data are required for the small watershed (assuming the required level of spatial disaggregation is the same for both) which means that targeting costs are lower. This guideline must be qualified because the relative proximity of the watersheds' outlets to damage sites affects the benefits of sediment reduction.

5.3 Policy Implications

Design of federal legislation

Our findings suggest that federal land retirement and other conservation legislation be designed to take advantage of cost effectiveness improvements offered by micro targeting. One way to facilitate micro-targeting is to recognize the effect that changing information technology can have on program implementation. Hardware and software intensive geographic information systems as well as simple computerized spreadsheets are likely to become less costly and more widespread in the years ahead. While such systems are unlikely to be developed at the local level solely to support NPSP reduction programs, they are attractive due to their flexibility in providing analytical support for a wide range of resource management programs. Once installed, the variable costs of applying such systems to specific problems is relatively low. Differential reductions in the cost of obtaining information on various targeting variables could conceivably affect the choice of targeting strategy. For example, information about physical variables may be more amenable to cost reduction than information regarding reservation prices.

Federal programs for land retirement, conservation easements, and other land management restrictions should, at a minimum, not discourage micro-targeting for water quality goals, and positive incentives should be considered. The type of targeting that is appropriate varies among watersheds according to the degree of heterogeneity among land parcels and the magnitude of the water quality problem. Federal legislation should be written in a manner that facilitates program flexibility at state and local levels.

In addition, federal funding for acquiring some or all cropping rights in a geographic area should be limited administratively as an incentive for targeting. At the same time, additional funds should be provided to collect and analyze data for more cost effectively allocating program payments. Under current arrangements for the CRP, for example, there is little incentive for administrative staff to pro-actively seek out those parcels of land whose enrollment would generate the highest per acre benefits. There is no overall funding limit (other than the 25% acreage limit and the per acre MARR), and administrative funds may be barely adequate to cover a reactive implementation mode (Kozloff, 1989). Current and proposed CRP acreage enrollment goals may be counterproductive from the perspective of government cost effectiveness in achieving environmental objectives.

While legislation can better facilitate targeting, potential cost effectiveness gains may be frustrated if programs attempt to achieve several conservation objectives with the same policy instrument. It is difficult to optimize several objectives with a single policy instrument (Tinbergen, pp. 39-42). We found that outlet cell sediment reduction imposes a different priority on land parcels than does on-site erosion reduction or soluble nutrient reduction. While not analyzed in this project, it is likely that conservation of soil productivity would impose an even greater difference in priorities. Even with those national programs for which the primary goal is nonpoint pollution control, there may be multiple local objectives (reduction in sediment deposition in water conveyances, improvement in clarity of downstream lakes, and objectives that may focus on sediment versus nutrients or episodic events versus ambient water quality).

The difficulty of optimizing more than one objective with a single policy instrument suggests that there needs to be better matching of objectives and policy instruments to facilitate both the technical and institutional aspects of micro-targeting. This could be accomplished by limiting the number of conservation objectives attached to a given policy instrument. Furthermore, federal legislation and local implementation could be explicit in establishing priorities among multiple (and possibly competing) program objectives. Alternatively, the number of policy instruments could be expanded. However, since policy instruments are rarely costless to implement, the increased cost effectiveness from better matching of objectives and instruments must be weighed against associated increases in administrative costs.

Finally, administrative guidelines established to implement federal programs should recognize that environmental objectives can be served by making payments that approximate reservation prices. By reducing the overpayment or underpayment for cropping rights, the government can exert greater control over which parcels become enrolled and thereby retain more funds to allocate to additional parcels. The policy instruments simulated in this study presumed that the government makes "take-it-or-leave-it" offers to landowners, a procedure that requires the government to have estimated individual reservation prices. An alternative for federal legislation is to promote or, at least, not inhibit the development of local procedures that induce landowner revelation of reservation prices. If incentive compatible policy instruments could be developed, cost effectiveness gains from matching (or more closely approximating) reservation prices could be realized without the need to develop reservation price data (Kozloff and Taff, 1990).

Local Implementation of Federal Legislation

Our research also has implications for state and local implementation of federal legislation. One is that better use can be made of available information about landscape heterogeneity to rank parcels for program eligibility for receiving payments. At present, for example, land is either eligible or not eligible for enrollment in CRP based on estimates of erodibility. The same estimates could be used to rank land parcels. Similarly, other land characteristics data that are readily available, such as location in watershed and stream channel proximity, could be used for parcel ranking. Such physical characteristics could be used to pro-rate payments levels as well.

As noted in Chapter 2, the theoretical efficiency gains of differentiated over uniform environmental control instruments depend on the steepness of marginal social benefit and cost curves. This suggests that the allocation of limited resources for targeting-related data collection versus actual payments should vary across watersheds. The problem is that it is difficult to compare the relative worth of targeting across watersheds ex ante. However, the guidelines listed in section 5.2 could be used to help allocate resources for data collection and analysis.

In voluntary programs, efficiency considerations must be balanced with acceptability among potential participants if efficiency goals are to be realized. In this case, acceptability may be related to whether the reasons for unequal treatment among landowners are apparent. If two or more targeting options appear to have comparable potential for cost effectiveness gains, local agencies should try to determine which option is likely to have the greatest landowner acceptability. For example, an option that pays fixed amounts for acquiring different cropping rights and targets parcels on the basis of erosion may be more acceptable to landowners than one that matches reservation prices for land retirements and targets on the basis of downstream erosion.

5.4. Caveats and Directions for Further Research

Caveats

The study has limitations with respect to both physical and economic relationships modeled as well as the lack of certain institutional considerations. In the first category, any modeling system necessarily simplifies physical and economic relationships. These simplifications can bias quantitative results regarding the cost effectiveness of alternative targeting schemes. Consequently, reported results are more reliable as indicating <u>relative</u> rather than absolute cost effectiveness of different policies in reducing nonpoint source pollution.

In addition, the characteristics of physical and economic variables in other watersheds could cause at least quantitative results to differ from those found here. Extrapolation of results to other watersheds must be done with caution since reasons for the superior performance of some targeting schemes over others are not always clear cut, even in relatively transparent models such as those used here. To the extent that the relative performance of targeting schemes in other watersheds is related to unknown statistical characteristics of relevant physical or economic variables, few generalizations are possible.

An important question is whether conducting the same analysis in other watersheds could give rise to conclusions and policy implications different from those realized here. The cost effectiveness gains from targeting are sensitive to landscape heterogeneity. Relative to other watersheds in southeast Minnesota, the RCW is only moderately heterogeneous, being located in a transitional zone between the corn belt and more rolling river valleys and karst topography to the east. If targeting is worthwhile in the RCW, it is also likely to be worthwhile in the substantial number of watersheds in southeast Minnesota that are more heterogeneous. The relative performance of different targeted policy instruments in response to different budget constraints is also likely to vary across watersheds in response to watershed characteristics discussed earlier.

Another technical question is whether our findings, such as those regarding off-site and the less expensive on-site measures of environmental sensitivity, reflect real world conditions or are only functions of AGNPS algorithms. This question is relevant to policy if the divergence between modeled results and real world conditions would result in substantially different rankings of cells and/or policy options. If (as discussed in Chapter 3) the apparent correlation between AGNPS-derived on-site and off-site variables might be biased upward, potential gains from targeting on the basis of the off-site variable may be underestimated. Perhaps the best indication of the quality of the physical model is not its accuracy in absolute terms, but whether it provides appropriate guidance to policy decisions, given the spatial and temporal scale at which those decisions are made.

Besides these technical considerations, the study is also limited in that it does not address certain institutional issues. While the original CRP legislation allows local environmental criteria to be used in program implementation, local agencies may not have incentives to make use of these provisions. Institutional resistance to targeting has been alluded to already and studied elsewhere (Nielsen 1985); however, some reasons for it bear repeating. First, targeting has equity implications; there is no reason to expect a positive correlation between financial need and environmental objectives. In fact, if environmental benefits are based on current land management practices, there may be a negative correlation between private need and social benefits. If equity considerations conflict with efficiency considerations, the historical precedent set by federal farm programs would tend to favor private needs, especially if cropping rights payments are viewed as entitlements. The combination of conservation objectives in general with wealth redistribution objectives renders targeting politically difficult to implement. Targeting inherently treats landowners differently on the basis of social objectives, regardless of their private economic circumstances. As long as policy instruments explicitly include wealth redistribution as an objective (or have that result) there may be resistance to targeting.

In addition, there may be additional transaction costs associated with a targeted policy instrument above and beyond data collection and analysis. Unless the policy instrument involves incentive compatible bidding, it may be necessary for the administering agency to approach high priority landowners individually to induce their participation.

The costs of more information-intensive policies need to be balanced against their benefits. The costs of targeting are primarily staff time and related expenses for data collection and analysis and administration. The benefits of targeting are measured as lower outlays to achieve the same level of program effects, an increased level of program benefits for the same outlay, or both. If <u>all</u> program effects remain at the same level, but necessary outlays decrease, then targeting benefits are simply the total dollar value of the decrease in expenditures over the watershed. However, if different objectives are affected differently by targeting (as is probable), measuring targeting benefits by changes in program effects requires that all the effects be monetized or at least quantified using policy weights or other units that can be compared across program options. For example, we found that some targeting options perform better with respect to downstream water quality improvement than with on-site erosion reduction, while the reverse is true with others. Unless some options outperform others with respect to <u>all</u> objectives associated with a land management program, the tools used in this analysis don't provide a basis for ranking the options.

Further research needs

There are several policy issues that this study was not able to address. In addition, the study raised some new issues. Given the magnitude of budget exposure fróm federal land and water conservation programs, payoffs from policy-relevant research that identify ways to improve program cost effectiveness are potentially large. In this section, several avenues for further research are discussed, including extensions of the basic framework used in this study, formal benefit/cost analysis of targeting incorporating uncertainty and risk, and field study of targeted policy instruments to understand how physical and institutional systems affect modeled results.

One extension of the model used here is to explicitly consider the trade-offs among multiple objectives from targeting land management programs. Because it is likely that new policy initiatives relating to nonpoint source pollution will encompass multiple objectives, it is important to accommodate the effects of multiple objectives on the cost effectiveness of targeting. Some program objectives may not be at all related to nonpoint source pollution control, as is the case with the CRP, whose objectives include preservation of soil productivity, reduction in government outlays associated with surplus commodity production, and enhancement of wildlife habitat. Data are available at the same spatial level to evaluate trade-offs among at least some of these objectives. For example, one could examine explicit trade-offs between environmental objectives and conservation of soil productivity using intertemporal models of soil erosion/fertility relationships.

To address the effect of targeting for reduction of one pollutant on the level of another, AGNPS could be run to several times to individually target for several different pollutants. One could then compare the relationship between individual cell contributions of one pollutant to other pollutant levels at the outlet. In addition, single event and annualized versions of AGNPS could be run to determine the difference made in targeting land parcels by episodic versus average ambient levels of nonpoint source loads.

One approach to the multiple objective issue is to monetize all objectives so that a single measure, dollars, is being maximized. Another standard approach is to assign subjective policy weights to the different objectives and then solve a multiple objective programming problem (Cohon and Marks, 1975). The effect of different targeting schemes and different levels of participation on the solution to the problem can be examined. There are also less formal approaches than mathematical programming that also involve assigning weights to different objectives (Nagel, 1987). Another approach, which does not require weights, is to establish criteria for selecting a single objective to maximize from among all program objectives. Possible criteria include the relative variance in benefits associated with participation of individual agents or the relative extent to which different program objectives would be achieved by private actions in the absence of positive or negative incentives offered by the program.

Another extension of the framework used would be to examine effects of other policy instruments besides cropping rights acquisition. In particular, targeting could be applied to policy instruments that are premised on different property rights assignments, such as Conservation

Compliance. To evaluate the effect of targeting Conservation Compliance for water quality, we could compare the current policy with alternative targeted approaches.

A potentially important topic for further research is to develop and test bidding schemes for programs in which the government is acquiring some or all cropping rights to serve environmental objectives. Economic theory suggests (and the present research supports) the potential for cost effectiveness gains of incorporating heterogeneity among land parcels' reservation prices in a cropping rights acquisition program. Under some conditions, it appears that such gains are larger than those realized by incorporating heterogeneity among the parcels with respect to their contributions to environmental quality. A limited watershed budget, combined with an environmental quality improvement goal, provides an incentive to government to neither under- nor over-pay farmers for acquiring their cropping rights. Unfortunately, farmers themselves have only an estimate of their true reservation prices and the government knows even less about those prices than farmers. The government could invest in obtaining information that would reduce, but not eliminate, its uncertainty regarding individual farmers' reservation prices. However, such an investment would reduce the government's budget remaining for actually acquiring cropping rights. The primary advantage of a bidding scheme over a take-it-or-leave-it offer scheme or "pseudo-bidding" schemes like the one used in the CRP is the potential for agents to reveal their estimated reservation prices through bidding behavior.[14] If farmers could be induced

[14] In this brief discussion, the deviation of farmers' estimated reservation price from the "true" reservation prices is assumed to based solely upon uncertainty regarding future states of the world (crop prices,

to do so, the cost effectiveness gains associated with reservation price heterogeneity could be achieved, while retaining more of the budget for actually acquiring cropping rights.

A final extension of the behavioral aspect of our framework would be to model the farmer's response to a given policy instrument more realistically. Farmers' decision rules regarding the CRP are thought to incorporate whole farm as well as intertemporal considerations.

A second major avenue for further research would be to more formally analyze benefits and costs of information required for targeting. The conceptual foundation for evaluating micro-targeting of policy instruments designed to improve water quality relies heavily on applying welfare economics and the economics of information to environmental control problems. To address the question of whether a given targeting scheme is worthwhile, it is necessary to compare social costs and benefits relative to some untargeted or less targeted base case. Unfortunately, while there is an extensive literature on conditions for maximizing social welfare with respect to environmental controls, there have been few "policy relevant" applications of information economics related to implementing environmental controls. Consequently, the gap between theoretical results and policy implications yawns wide.

There are at least two reasons why a more formal and explicit treatment of the value of information in reducing uncertainty may be worthwhile:

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yields, etc.) and not upon the bidding behavior of other farmers. Of course, the actual amount a farmer bids can be affected both by estimated own reservation price, risk attitude, and bidding behavior of others. The distinction between true and estimated reservation prices should not affect the outcome of a bidding scheme unless farmers are able to update their estimates and then opt in or out of the program.

1) Perfect information in the sense of ex post values is unrealistic. A watershed manager is not likely able to run AGNPS to determine the outcome of a given option in advance of making offers to landowners or opening up an enrollment period.

2) Both farmers and watershed managers are likely to be risk averse, so expected values alone may not indicate a ranking of program options from their respective accounting perspectives. In many watersheds, there is some threshold value of reduction in sediment or nutrients below which water quality benefits are insignificant. Water quality may be more a function of severe storm events than average ambient conditions in some watersheds, while the reverse may be true elsewhere. Both of these factors argue for taking reductions in variance as well as increases in mean sediment reduction into account in choosing among policy options.

There are several ways risk could be incorporated into our existing modeling framework. One way is to impose reliability constraints on the objective function. Another approach is to include uncertainty in the government's objective function with some policy weights assumed for sediment reduction and variance in sediment reduction. For example, the optimization problem could be formulated to maximize expected sediment reduction less a weighted variance of sediment reduction.

A third major avenue of research is field study in a watershed or watersheds of the more promising simulated targeting options in a watershed or watersheds. We have already alluded to several factors that could cause divergence between simulated and actual cost effectiveness gains from targeting: agency-level institutional constraints, farmer responses to program offerings, and physical responses to land management changes, among others. The magnitude of the long term financial commitment associated with national programs like the CRP suggest the value of a research phase between policy simulation and full scale program implementation. Furthermore, we hypothesize that the effect of the above factors would be to decrease actual cost effectiveness gains from those simulated under our somewhat idealized conditions.

To limit the opportunity costs of delaying decisions about program implementation, field studies could be conducted in two phases. In the first, agency-level implementation and farmer-response issues could be tested. The phase would provide data on the agency's application of analytic tools to develop a targeted policy instrument and the extent to which a given policy instrument can actually cause management changes on targeted land parcels. The second phase could monitor the short and long term response of the physical system, in terms of NPSP reduction, to the indicated land management changes. Results from the first phase of field research could be available relatively quickly and may provide sufficient guidance to eliminate certain targeting options and make other program implementation decisions. Results from the second phase could be used to refine the application of physical models for targeting as well as to evaluate program cost effectiveness.

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