The Importance of Spatial Data in Modeling Actual Enrollment in the Conservation Reserve Enhancement Program (CREP)

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Introduction

Agriculture is recognized as the largest source of surface water quality impairment in the United States and has been identified as the leading cause of pollution in 48 percent of impaired river miles and 41 percent of impaired lake acres nationwide (US EPA 2000). The U.S. has operated voluntary, incentive-based programs to deal with these issues since the 1930's, delivered through a national network of county soil and water conservation districts. Since the mid 1980's, the principal focus has been on conservation compliance and retirement of highly erodible land through enrollments in the Conservation Reserve Program (CRP). At present, land retirement programs have an annual budget exceeding $2 billion, while conservation programs for working farms (such as the Environmental Quality Incentives Program) have a budget of less than $1 billion (USDA ERS 2002).

The CRP currently has an enrollment of approximately 34 million acres and an annual budget of over $1.6 billion (USDA FSA 2002). The Conservation Reserve Enhancement Program (CREP), which is the focus of this paper, is a subset of the CRP that addresses specific environmental issues in targeted locations. CREP differs from the traditional CRP because it combines state and federal level funds to target specific geographic areas and conservation practices (USDA FSA 2003b). The incentives offered under CREP are higher than the incentives offered under the traditional CRP and the cash incentives also can vary materially from one site to the next.

The stated goal of CREP is *"to address specific conservation objectives of a State and the nation in a* ***cost-effective*** *manner"* (USDA FSA 1999). This paper addresses the information necessary to assess the cost-effectiveness of the program. Namely, we develop an economic model for determining the responsiveness of landowners to the financial incentives offered under CREP. To attain cost-effectiveness, the amount of funding that is offered to landowners to retire land must be set so as to induce an exogenously determined amount of acreage retirement. If incentive rates are set too low, then acreage enrollment will not be high enough to meet the environmental objectives of the program. Similarly, setting incentive rates too high, i.e. above rates needed to secure the desired participation levels, will lead to inefficiencies either in terms of excessive enrollment when budget levels are flexible or inadequate enrollment because high rates prematurely exhaust the budget constraint.

Our analysis departs from previous research, which has largely relied on hypothetical enrollment decisions in localized study areas. Instead, we analyze data on actual enrollment rates and incentive levels in six geographically diverse states. In addition, rather than relying on potentially biased county averages, this research makes a novel contribution to the literature by using Geographic Information System (GIS) data to estimate the amount of eligible land and the average incentive levels offered to farmers.

To provide a point of departure, we first give a brief background on CREP and summarize the land retirement literature. We then specify the economic model used to estimate enrollment levels in 218 counties in six states and go on to explain the significance of the results and their relevance to policy makers.

Background on the Conservation Reserve Enhancement Program

The Conservation Reserve Program was initiated by the Food Security Act of 1985 to protect water quality, reduce soil erosion, control supply and improve wildlife habitat by encouraging landowners to convert highly erodible cropland to vegetative cover (USDA FSA 1999). Landowners enroll their land in the CRP via participation in periodic competitive auctions called General Signups. Landowners that submit competitive bids are eligible to receive annual rental payments based on the Farm Service Agency (FSA) determined agricultural rental value of the land.

Noting that targeted intervention towards “high environmental risk” farms or high priority water bodies may be more cost-effective in meeting water quality objectives, the 1996 Farm Bill (the Federal Agricultural Improvement and Reform Act) made two more significant additions to the Conservation Reserve Program.

First, a Continuous Signup option was created that targets high value environmental practices such as filter strips, riparian buffers and wellhead protection areas. Farmland meeting the program’s criteria can be enrolled at any time at the maximum determined average rental rate for the enrolled soils, avoiding transaction costs and uncertainties surrounding the bidding process of the periodic general signups (USDA FSA 1999). Over 1.7 million acres are currently enrolled in the Continuous Signup CRP (USDA FSA 2003a).

The second addition to the CRP resulting from the 1996 Farm Bill, was the creation of the Conservation Reserve Enhancement Program (CREP). As noted above, CREP combines federal and state dollars to target specific geographic areas and conservation practices (USDA FSA 2003b). Payment rates under CREP are higher than rates under the traditional CRP and Continuous Signup CRP so as to entice landowners to enroll critical acreage into the program. To date, 26 CREP sites have been approved in 24 states covering proposed enrollments of 1,393,310 acres. CREP sites can be as small as an individual watershed, such as in the New York- Syracuse CREP, or can encompass an entire state, such as the Maryland CREP.

There are over 20 types of conservation practices available for enrollment under CREP, with the most prominent being riparian buffers[1] (23.4% of land enrolled). Filter strips, wetland restoration and planting of tame grasses are the second, third and fourth most popular, comprising 20.3%, 17.8% and 13.8% of total enrollment respectively.

Review of the Literature

In recent years several studies have examined the relationship between incentive rates and enrollment in voluntary conservation programs. In the discussion that follows we categorize these studies by whether the analyses used hypothetical response data obtained through contingent participation studies or focused on actual enrollment rates and incentives. We regard these efforts as being complementary. Hypothetical studies usually focus on localized programs and provide greater detail about individual responsiveness to increasing incentives and the individual or operation-based covariates that may impact this responsiveness. Yet whether such hypothetical enrollment information predicts actual enrollment responsiveness to incentives remains an open empirical question. Studies of actual enrollment levels do not suffer from possible hypothetical biases, but, by necessity, have relied on aggregate data for determining enrollment rates that may also lead to biased estimates of responsiveness to incentive levels. With an eye toward informing our own analysis, we briefly review these studies.

Lohr and Park (1995) used hypothetical survey data from a county in Illinois and a county in Michigan in which respondents made hypothetical enrollment decisions to

[1] The term "riparian buffer" is used by the USDA to indicate that trees are planted on the land adjacent to rivers and streams. Riparian land with grass cover is referred to as a filter strip.

enroll land in a filter strip program. They employed a two-step probit model, in which the first step predicts the enrollment decision and the second step predicts the number of acres enrolled. Their results indicate that farmers in the Illinois county were willing to accept $80 on average as compensation for enrolling an acre of land, while the farmers in Michigan were willing to accept a much lower amount of $38.

In an analysis of hypothetical adoption rates of five conservation programs, Cooper and Keim (1996) used a random utility model (RUM) to show that for four of the conservation practices, a $10 increase in the incentive offered would lead to approximately 5% of current nonusers to adopt the practice. The fifth conservation practice, split levels of nitrogen, shows a steeper response curve. A $10 increase in incentive payment leads to an approximate 10% increase in participation. The authors conclude then that the current incentive payment of $10 per acre will not be enough to encourage a large percentage of farmers to join any of the five programs.

A subsequent article by Cooper and Osborn (1998) looks more specifically at the link between the rental rate offered and the level of land retirement. A sample of farmers that currently participate in the CRP and whose land is coming up for re-enrollment was used in the analysis. The farmers were surveyed to determine whether or not they would re-enroll based on varying levels of rental payments. A probit regression was used to determine the probability of re-enrollment given a rental offer. Based on the yes or no response to the hypothetical participation decision and the number of acres that the farmer currently has enrolled, a schedule of CRP acres as a function of the rental price was created.

More recently, Lynch, Hardie and Parker (2002) had the objective of understanding the factors affecting landowners' willingness to accept incentives to install riparian buffers under CREP. Their analysis focused on determining how the hypothetical enrollment responsiveness to varying CREP incentives responded to agricultural opportunity costs and real estate development potential. The authors estimate a RUM and conclude that the likelihood of installing a buffer increases with higher levels of incentive payments, a low percentage of income coming from farming, age of the farmer, and geographic location in all three models. Interestingly, they find a negative and significant relationship for the variable that represents farmers who expect to hold their land in the future rather than sell it for development. According to the authors, their most significant finding was that the probability of adding a buffer could be increased from 1.1% to 1.4% by a 1% increase in the incentive rate.

Modeling actual rather than hypothetical enrollment, Konyar and Osborn (1990) estimated a national CRP enrollment model using actual enrollment rates in the CRP across the United States. Since national data do not exist for farmers that were eligible for the program but did not enroll, the authors' analysis is based on regional level variations in average farm characteristics as opposed to individual farm level variations. The variable used to explain the financial incentive offered was the net returns from CRP minus the net returns from nonparticipation, which were estimated using the average CRP payments from the contract database and USDA data on average net returns from agriculture. The incentive variable, along with land value, tenure, farm size, age and erosion potential all significantly explained variations in farmer participation in CRP.

Parks and Schorr (1997) also used data on actual enrollment decisions in an attempt to explore why only 7.5% of eligible land in the Northeast is enrolled in the CRP whereas 54.2% of eligible land in other regions is enrolled. The authors estimate two separate equations that describe a farmer's willingness to participate in the CRP. The first equation uses data from counties defined as nonmetropolitan while the second equation is uses data from metropolitan counties (defined by the Census of Population).

The most interesting result from, the perspective of this analysis, is the differences observed in the factors motivating farmers in metropolitan and nonmetropolitan areas. In the case of nonmetro counties, a farmer's decision to enroll land is significantly influenced by the incentive payment offered by the USDA. The same is not true, however, for metropolitan counties where the authors conclude, "the influence of CRP payments cannot be distinguished from zero."

Although the actual enrollment data used by Konyar and Osborn as well as Parks and Schorr would potentially provide a better basis than the hypothetical enrollment data, the aggregate proxies used for the incentives offered to landowners are potentially problematic. Konyar and Osborn used the average incentives received by landowners that enrolled, not the average incentives that were offered in each region. Hence, their estimates may be biased because they did not correct for selection.

The incentive variable used by Parks and Schorr is also potentially biased since they relied on the maximum allowable rental rate in each county. Although the maximum rate does vary across counties, it does not represent the incentive offered to farmers since enrollment is based on a competitive bidding process. Also, by not allowing the rental rate to exceed the maximum rental rate it is impossible to determine the true response of farmers to higher offers because of the classic problem of extrapolation. Another potential problem with the analysis done by Parks and Schorr is that the number of eligible CRP acres are estimated using National Resource Inventory (NRI) data. The NRCS states that NRI data are not accurate at the county level due to the nature of the statistical sampling (USDA NRCS 1997)[2].

Economic Model of Enrollment

Although it is possible to imagine structural changes in the land enrollment process that would make CREP more efficient, this analysis is focused on ways of reducing costs given the current rules of the program. Assuming that all the CREP designated conservation practices are of equally high priority, which is consistent with the immediate acceptance of such high priority practices in the continuous signup, the cost-effective enrollment of a predetermined number of acres could be achieved by paying each farmer the minimum amount they would accept to retire land. This would result in the retirement of the "least cost" parcels. However, attempting to determine the minimum amount an individual farmer would accept without some type of auction mechanism imposes extremely high transaction costs on program administrators and would be inconsistent with the current rules of the program.

Estimating the minimum payment required to induce a predetermined level of enrollment on a countywide basis is a more feasible approach based on the information costs required. Understanding how the magnitude and mix of incentives affect the amount of land enrolled will allow states to set their incentives at the appropriate level

[2] Lynch and Lovell (2003) used actual data from enrollment in three farmland preservation programs in Maryland, however, a variable measuring the effect of incentive rates was not included, as the incentive rates did not vary across the study area. The authors used GIS data pertaining to the types of soils, farm size, and the distance of the farm to the nearest major city. The regression results indicate that eligibility, distance to the nearest city, farm size, off-farm

given the environmental goals and therefore achieve their objective at a lower cost. This approach corresponds to what Ferraro (2002) calls "cheap land" targeting.

More formally the objective is to:

Minimize: $\sum PPA_i$ **x** $ACRE_i$ **S. T.:** $\sum ACRE_i \geq EG$

Where: PPA_i = Price for the ith acre ($ACRE_i$) enrolled in CREP

EG = Environmental Goal (Exogenously Determined)

This approach assumes that all eligible acreage has essentially the same environmental value and that program administrators know the relationship between acreage retirement and environmental quality in the watershed. This allows the administrators to determine the minimum amount of acreage necessary to meet the environmental goals.

To estimate the relationship between the incentives offered and county level enrollment rates in the study area, it an economic model is needed. Although, by necessity, the objective is to evaluate the relationship at the county level, it is appropriate to begin the analysis at the level of the individual decision-maker.

Typically the farmer level enrollment decision process has been modeled using a RUM approach (see for example Lohr and Park 1995; Cooper and Keim 1996; Lynch, Hardie, and Parker 2002; Lynch and Lovell 2003). The model is based on the assumption that each farmer with eligible land decides whether or not to enroll in CREP based on comparisons of his or her expected utility across their alternatives. If the expected utility of retiring acres in the program is greater than the utility of farming the land, then it is assumed that the farmer will enroll. While utility will be a function of

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opportunities, knowledge of the program and having children who plan to continue farming all significantly affect participation in the program.

individual characteristics, it is assumed that expected utility in the case of an individual landowner will be a function of the incentive payments offered and conditioning characteristics that affect the landowners willingness to accept compensation. Formally, a landowner will enroll in the program if:

$$V_1(y + \mathbf{\Delta y} ; \mathbf{c}) + \epsilon_1 > V_0(y ; \mathbf{c}) + \epsilon_0 \quad (1)$$

Where, V_1 represents the portion of the landowner's utility function that is visible with enrollment and V_0 represents utility given non-enrollment. The net income of the farm without retiring acres is given by y and Δy is the amount that net income is expected to change given the incentive levels of the program. The vector of conditioning characteristics is represented by **c**.

The probability of a farmer enrolling acreage into the program can be represented by:

$$\Pr \{\text{enrollment}\} = \Pr \{ V_1(y + \mathbf{\Delta y} ; \mathbf{c}) + \epsilon_1 > V_0(y ; \mathbf{c}) + \epsilon_0 \} \quad (2)$$

Rearranging terms and representing $\epsilon_0 - \epsilon_1$ by $\Delta\epsilon$ and $V_1 - V_0$ by ($\mathbf{\Delta y}$; **c**) the probability of enrollment becomes:

$$\Pr \{\text{enrollment}\} = \Pr \{ \Delta\epsilon < \mathbf{\Delta y} ; \mathbf{c} \} \quad (3)$$

The right hand side (rhs) of equation (3) can then be approximated linearly by:

$$(\mathbf{\Delta y} ; \mathbf{c}) = \alpha + \mathbf{\Delta y}'\beta_1 + \mathbf{c}'\beta_2 \quad (4)$$

As defined previously, $\mathbf{\Delta y}$ represents a vector of the incentives offered to the farmer, **c** represents a vector of conditioning characteristics that may influence the farmer's WTA.

Given this basic framework depicting the probability of an individual farmer participating, the next step is to model the farmer's decision of how many acres to enroll in the program. To estimate the number of acres a farmer will retire under CREP, the assumption made is that the same factors that influence the decision of whether or not to enroll in the program are the same factors that affect the number of acres that the farmer chooses to enroll.

It is theoretically possible to separately estimate the decision of whether or not to enroll and the decision of how many acres to enroll (see for example Lohr and Park 1995). The number of riparian acres retired per contract in the six-state study area is on average less than 13 acres. The average farm size of landowners that enrolled acreage in the six states is 204 acres and therefore the amount of riparian land retired averages approximately 6% of the total farm size. The small percentage of land per farm retired under CREP suggests that the decision of how many acres to enroll is closely related to the decision of whether or not to enroll in the first place. Therefore we assume here that the same set of factors influence the decision of whether or not to enroll and how much land to enroll. This assumption is further supported by the fact that aggregate data are used, because enrollment rates are based on the decisions of all eligible landowners.

A logical extension of the individual RUM approach used in hypothetical participation analyses would be to adopt an analysis of proportions approach. This approach would model the percentage of eligible acres enrolled as a function of the explanatory variables. Parks and Schorr (1997) as well as Konyar and Osborn (1990) used the percentage of eligible acres enrolled as the dependent variable in their analyses of enrollment in the CRP. The authors estimated the models as a grouped logit, and applied the minimum chi squared (MCS) approach.

The major drawback to using the grouped logit method in this analysis of CREP is that 22% of the counties in the sample have zero eligible acres enrolled. This creates a problem for the MCS estimation method, since it is undefined for the zero values (Greene 2000). In addition, the range of the proportion of eligible acres enrolled is fairly concentrated around its mean of 1.4%. In fact only 9 of the 218 counties had more than 10% of their eligible acreage enrolled.

Instead of the grouped logit method, this analysis relies on a transformation of the proportion participation function. Essentially this involves shifting the denominator of the percentage enrolled (acres enrolled / eligible acres), to the right hand side of the equation. As such, the dependent variable is acres enrolled as a function of the eligible acreage and the other explanatory variables. The model used to estimate the number of riparian acres that a farmer will retire is therefore given by the equation:

$$\text{ACRES} = \alpha + \mathbf{\Delta y}'\beta_1 + \mathbf{c}'\beta_2 + u_i \tag{5}$$

Given the lack of data on individual farms, the final step in the modeling process is to determine the relationship between the number of acres enrolled in a county and the incentive rates offered to farmers. Aggregating to the county level implicitly allows for the use of data for farmers who did not participate in the program. Since the farms identified in the CRP contract database do not contain any descriptive data, utilizing data from the county level is vital for including the necessary control variables.

To aggregate the individual farm level model to the county level, one more assumption is made. Following the analysis done Parks and Kramer on enrollment in the Wetlands Reserve Program (1995) and Parks and Schorr on CRP enrollment (1997), this analysis assumes that the average characteristics of each county can be treated as if they were a representative farm in that county. The average county level values are treated as if they were indicative of a typical farm in that county. The corresponding assumption is that landowners in a county are all attempting to maximize the same utility function. The theoretical model to explain county level enrollment can then be treated identically to the model developed above to explain an individual farmer's acreage enrollment decision.

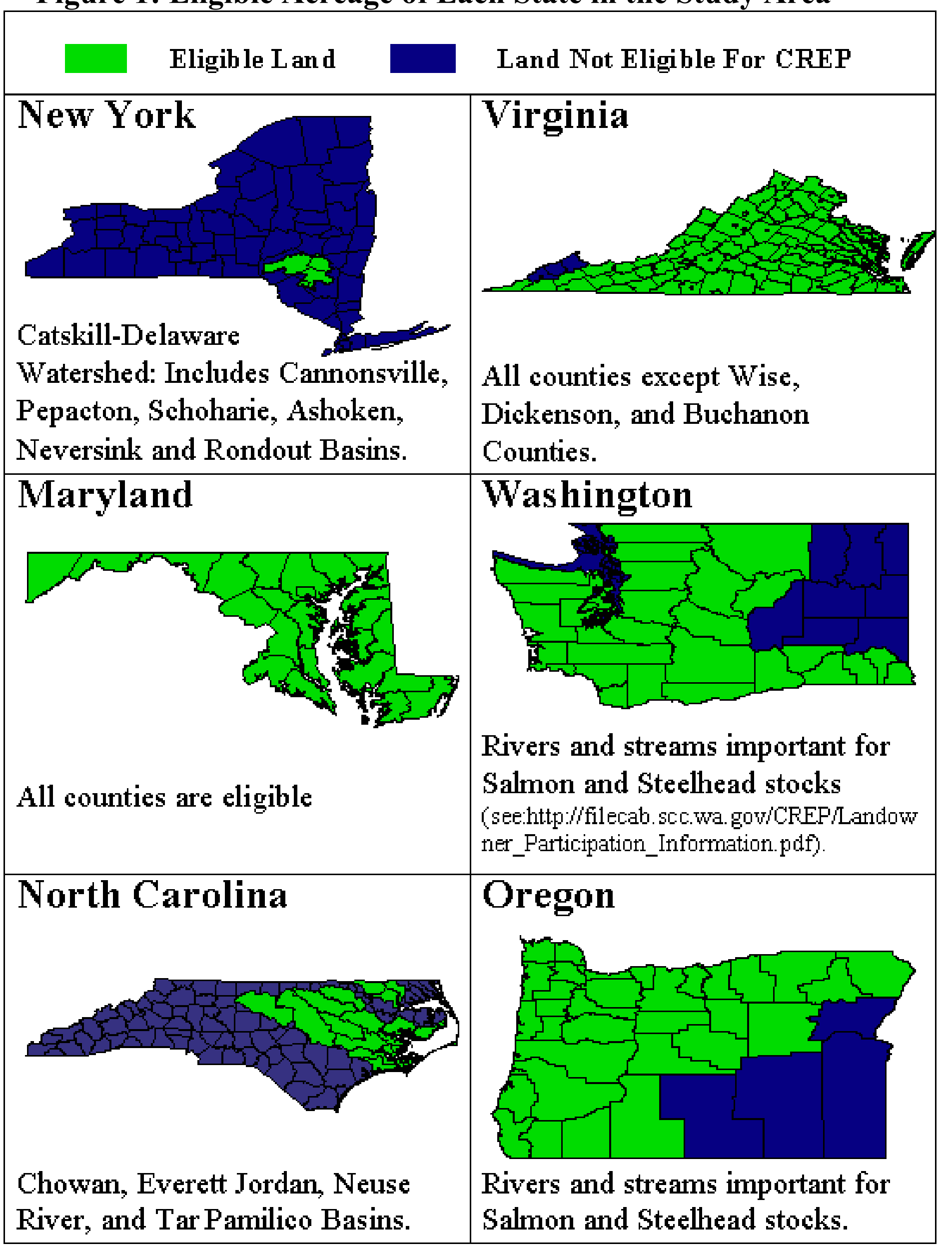
Implementing the Model

To estimate the relationship between incentive rates and enrollment in CREP, we narrowed our focus to agricultural land enrolled as wooded riparian buffer acres--representing 23.4% of all retired acres. The study area was further restricted to the states of Maryland, New York, North Carolina, Oregon, Virginia and Washington to ensure that only states that have had CREP agreements in place for at least two years were evaluated. This limits the variability that will result from the rate at which farmers sign up for the program. To account for any remaining time related effects, a variable is included that captures the length that CREP has been available to farmers in each state.

The second criteria for selecting states to include in the study area is that riparian buffer acres must account for at least 23.4% of the acres enrolled into CREP in the state. The level of 23.4% represents the nationwide average proportion of CREP acres enrolled in the riparian buffer practice. Although somewhat arbitrary, this ensures that only states with a substantive commitment to the riparian buffer conservation practice are evaluated.

After reducing the study area to the enrollment of riparian land in six states, the next step was to determine the counties that contained land eligible for enrollment. States often restrict acreage eligible for CREP to land that falls inside a specific watershed or that meets a specific requirement. For instance, in the New York Catskills CREP, agricultural land must fall inside of the New York City Watershed to be considered eligible. The New York City Watershed is comprised of six watershed basins located in the Catskill Region. Since watershed boundaries do not coincide with county boundaries, the amount of the eligible watersheds that fall within each county must be accounted for. Counties that lie completely outside of the eligible watersheds can then be left out of the analysis. Figure 1 includes a map of the eligible land in each state as well as a description of the criteria used to develop the eligible area. Note that the entire states of Maryland and Virginia (with the exception of three counties in Virginia) are eligible.

Figure 1: Eligible Acreage of Each State in the Study Area



After eliminating counties that did not contain eligible land, the end result is the creation of a dataset that is made up of 218 counties. The breakdown of the number of counties in each state is included below as Table 1.

Table 1: Number of Eligible Counties in Each State

State	Eligible Counties
Maryland	23
New York	5
North Carolina	42
Oregon	32
Virginia	88
Washington	28
Total	218

The quantity of riparian buffer acreage enrollment in each county is the dependent variable in this analysis, and was calculated using the USDA CRP Contract Database. The explanatory variables are grouped into two main categories, representing the incentives offered to landowners and the set of conditioning characteristics that may influence landowners' willingness to accept compensation for enrollment.

Included in the set of conditioning characteristics is the amount of eligible land in a county. GIS data were used in the calculation of the number of eligible acres in each county through four primary steps. First, maps containing land use data (obtained from the EPA), maps of rivers and streams (obtained from the USGS) and a map of watershed boundaries (also obtained from the USGS) were added to a map of the county boundaries in each of the six states. Second, a buffer was added to all of the rivers and streams in each of the eligible watershed in the six states. Third, all of the agricultural land inside of the buffered areas was identified. Fourth, the agricultural acreage was summed up by county to come up with the measure of eligible acreage.

While it is possible to include estimates of the amount agricultural land and number of river and stream miles in a county without the use of GIS data, it is necessary to understand the correlation among the two components to get an accurate estimate of eligible acreage. For instance, it is possible that a county could have a large number of agricultural acres and a large quantity of river and stream miles, but without knowing the spatial location of the agricultural acres in relation to the rivers and streams, we cannot get an accurate estimate of the number of eligible riparian acres. By using GIS data, the two components can be simultaneously incorporated in each county to come up with one measure of eligible riparian acreage.

Two variables representing the incentives offered to landowners are included in this analysis. The first variable represents the annual incentive that landowners can receive for enrolling in the program. The annual incentive rate has two primary components. First, the incentive is based on the rental rate of the soil that is to be retired. Second, this rental rate is multiplied by a percentage incentive rate that varies by state from 150% to 220%. For example, if the soil rental rate is $40 per acre and the percentage incentive rate is 200% then a landowner would be eligible to receive $80 per acre the he or she retires.

To get an unbiased estimate of the annual incentive rate offered to landowners, GIS data were used to calculate the average rental rate of the soil in each county. This was accomplished by overlaying the map of the eligible acreage onto a map of soil types. The total area of each soil type in each county was then determined for each county in study area. The USDA provided the soil rental rate data for each soil type in each county, which were then merged with the total area of each soil type. A weighted average rental rate was then calculated using the percentage of each soil type in the eligible areas as the weight. In cases where the soil type from the GIS data could not be matched up with the soil type in the rental rate data, the average soil rental rate in that county was applied.

The incentives offered for the enrollment of pastureland differ from the incentives offered for cropland in some of the states. For this reason, the percentage of pastureland in each county in the study area was calculated using data from the 1997 Census of Agriculture. A final weighted average of the soil rental rate and the marginal pastureland rate was then calculated where applicable using the percentage of pastureland in the county as the weight. The improved county average rental rate was then multiplied times the percentage incentive rate to estimate the annual incentive rate.

The second type of incentive offered to landowners is a one-time payment made for entry into the program. This variable is a sum of the signing bonus payment and the cost share amount, minus the actual costs of setting up the conservation practice (planting trees, removing fences, etc.). The cost share amount and the actual costs were determined using the CRP contract database. The bonus payment offered to farmers in each state was given by Farm Service Agency documents (USDA FSA 2003b). In counties where zero acres were enrolled, there are no contract data on which to determine the costs of enrollment. In such cases, the average one-time payment for all counties in the state is applied. The one-time payment was then annualized so as to make it directly comparable to the annual incentive variable.

The next set of explanatory variables represent the conditioning characteristics that may influence landowners' willingness to pay. The variables representing average farm income, average value of machinery, percentage of irrigated cropland, number of cattle per acre, average property tax, land tenure, and average farm size come from the 1997 Census of Agriculture available from the USDA National Agricultural Statistics Service (NASS).

Beyond the variables obtained from the Census of Agriculture, the amount of development pressure experienced by the average farm in a county is included in the model. This variable was calculated using the Urban Influence Index for each county as determined by the Economic Research Service at the USDA. The variable measures the percentage of land that is located in close proximity to a metropolitan area.

A variable representing the amount of acreage enrolled in the traditional CRP is also included and was calculated using the CRP Contract Database. If a large quantity of acreage has already been retired through the traditional CRP, this leaves less acreage available for enrollment in CREP and therefore we expect the CRP variable to be negative. The amount of time that CREP has been available to farmers in a county is also used as a conditioning variable in the analysis. The variable is defined in terms of the number of months since the first retirement contract in the state was signed.

Finally, a variable that attempts to measure the level of information that landowners receive about the program is included. This variable is the amount of funding allotted to each county per farm by the Farm Service Agency (FSA), the agency in charge of administering CREP. The budgetary data were received for the 2002 fiscal year from the FSA. Since the FSA is also responsible for administering the CRP, it is possible that there will be collinearity between the FSA budget variable and the CRP variable. Interestingly, however, the correlation coefficient between these two variables is not significantly different from zero. A summary of the explanatory variables is included below in table 2.

Table 2: Description of Variable Names and Summary Statistics

	Variable Name	Definition	Units	Range	Mean	Standard Dev
Net Gain	ANNUAL INCENTIVE	Average annual incentive per acre offered to farmers	Dollars	22.94 – 129.91	52.38	16.41
	ONE TIME PAY	Average annualized one-time incentive (cost) of enrollment	Dollars	-4.39 – 20.93	12.60	5.96
Conditioning Characteristics	CATTLE	Number of cattle per acre per county	Cattle	0.004 – 1.16	0.15	0.16
	DEVELOP	County Development Index	Index	0 – 3	0.53	0.81
	INCOME	Average net cash returns from ag sales per county	Dollars (Thousands)	-19.5 – 215.0	22.77	30.42
	IRRIGATED	Percentage of irrigated cropland per county	Percent	0 – 66.0	4.6	8.4
	OWNER	Percentage of owner operated farms per county	Percent	7.7 – 75.20	38.2	14.3
	SIZE	Average farm size per county	Acres	38 – 4,474	376.71	584.58
	TAXES	Average property taxes collected per acre per county	Dollars	0.7 –77.1	10.80	10.49
	VALUE MACHINE	Average value of machinery per county	Dollars (Thousands)	16.6 – 217.5	59.56	34.12
	ELIGIBLE	Number of eligible acres per county	Acres	33.1 – 67,177.1	10,308.54	10,460.19
	BUDGET	FSA payroll per farm per county	Dollars	17.07 – 2,152.13	375.65	347.38
	CRP	Number of CRP acres enrolled not including CREP	Acres	0 – 187,733.1	5,896.81	22,729.56
	LENGTH	Length of time that CREP has been available to farmers	Months	24.33 – 58.83	36.01	11.13

Results

The explanatory variables above are used to estimate a Tobit model, with the number of acres enrolled as riparian buffers serving as the dependent variable.

Specification of the Tobit model makes the underlying assumption that the same set of factors that influence the discrete choice of whether or not to enroll also affect the continuous portion of the decision of how many acres to enroll. This assumption is congruent with the modeling assumption made earlier that the same variables influence a landowner's decision to enroll and the decision on how many acres to enroll.

Table 3: Estimation Results

	Base Model			**Model Variation 1**			**Model Variation 2**		
Variable	**Coefficient (S.E.)**	**T Value**	**Marginal Effect**	**Coefficient (S.E.)**	**T Value**	**Marginal Effect**	**Coefficient (S.E.)**	**T Value**	**Marginal Effect**
INTERCEPT	-727.66 *(245.93)*	-2.96**	-448.60	-727.56 *(246.105)*	-2.956**	-448.25	-333.64 *(236.49)*	-1.41	-205.76
ANNUAL INCENTIVE	6.82 *(2.86)*	2.38**	4.20	-	-	-	-	-	-
ONE TIME PAY	9.17 *(9.78)*	0.94	5.65	-	-	-	-	-	-
TOTAL INCENTIVE	-	-	-	7.01 *(2.74)*	2.56**	4.32	0.40 *(1.09)*	0.37	0.25
CATTLE	382.73 *(288.43)*	1.33	235.95	384.88 *(288.54)*	1.33	237.12	630.55 *(297.76)*	2.12**	388.90
DEVELOP	-235.19 *(56.93)*	-4.13**	-144.99	-230.70 *(53.51)*	-4.31**	-142.14	-180.34 *(54.81)*	-3.29**	-111.22
INCOME	-0.61 *(1.56)*	-0.39	-0.37	-0.50 *(1.49)*	-0.33	-0.31	-0.32 *(1.59)*	-0.20	-0.20
IRRIGATED	-24.76 *(6.56)*	-3.77**	-15.26	-24.86 *(6.55)*	-3.80**	-15.31	-26.05 *(6.77)*	-3.85**	-16.06
OWNER	-2.81 *(3.39)*	-0.83	-1.73	-2.84 *(3.39)*	-0.84	-1.75	-4.65 *(3.61)*	-1.29	-2.87
SIZE	0.073 *(0.079)*	0.91	0.045	0.072 *(0.079)*	0.90	0.044	-0.12 *(0.088)*	-1.37	-0.074
TAXES	-4.05 *(5.86)*	-0.69	-2.49	-4.67 *(5.20)*	-0.90	-2.88	-6.19 *(5.24)*	-1.18	-3.82
VALUE MACHINE	1.41 *(1.97)*	0.72	0.87	1.38 *(1.97)*	0.70	0.85	3.76 *(2.02)*	1.86	2.32
ELIGIBLE	0.022 *(0.004)*	5.22**	0.014	0.022 *(0.004)*	5.22**	0.013	-	-	-
TOTAL LAND	-	-	-	-	-	-	0.0004 *(0.0002)*	1.56	0.0002
BUDGET	-0.073 *(0.153)*	-0.48	-0.045	-0.066 *(0.15)*	-0.44	-0.041	-0.21 *(0.15)*	-1.39	-0.13
CRP	-0.006 *(0.002)*	-2.76**	-0.004	-0.006 *(0.002)*	-2.87**	-0.004	-0.003 *(0.002)*	-1.29	-0.002
LENGTH	12.74 *(4.67)*	2.73**	7.85	13.299 *(3.987)*	3.336**	8.193	18.235 *(3.909)*	4.664**	11.246

** Indicates coefficients significantly different from zero at the 95% confidence level

The results of the Tobit model indicate that the variable representing the annual incentives made to farmers is significant and positive. The estimated marginal effect is 4.2, meaning that if the annual incentive is increased one dollar then we would expect enrollment in a county to increase by slightly more than four acres. Although the variable representing the one-time payment offered to farmers is positive, it is not significantly different from zero. The lack of significance is most likely a result of the fact that observations for counties that did not participate had to be estimated using the average for that state. The averaging reduces the degree of variability and therefore reduces the variable's explanatory power.

The results of a likelihood ratio test show that the coefficients of the ANNUAL INCENTIVE and ONE TIME PAY variables are not significantly different. The resulting test statistic of 0.052 is not significantly different from zero, based on the chi-squared distribution with one degree of freedom. This result suggests that landowners are indifferent between payments received up front and payments that are spread out over time. The equality of coefficients also means that lumping the two variables together to form a total payment variable is appropriate.

The conditioning variables that represent the amount of development pressure and the percentage of irrigated land in the county are both significantly different from zero. The greater the pressure to sell land for development, the lower the levels of enrollment. Similarly, the greater the percentage of irrigated cropland, the less land that gets enrolled. A farmer that has expended large amounts of resources on irrigation equipment on her land is less likely to enroll the land and lose the benefits of that irrigation equipment.

As expected, the amount of eligible land in a county is positively related to the amount of acres retired. According to the model, for every additional acre that is eligible it is expected that approximately 0.014 acres will be enrolled in the program. The results also indicate that the greater the length of time that CREP is available to farmers the greater the levels of enrollment. Finally, the variable representing the amount of CRP enrollment in the county is negative and significant. This supports the hypothesis that farmers are less likely to enroll additional land in counties where a large amount of land has already been retired.

Based on the results of the likelihood ratio test, the first variation of the original model lumps the two incentive payments into one variable called TOTAL INCENTIVE. The TOTAL INCENTIVE variable represents the present value of the income per acre that a landowner can expect to receive by enrolling in the program. The estimated coefficient of the TOTAL INCENTIVE variable is 7.01, which is significantly greater than zero. The marginal effect of 4.32 on the TOTAL INCENTIVE means that for every one dollar increase in payment offered to landowners, it is expected that approximately four acres of additional land will be enrolled. The other coefficients in the model were not noticeably affected by creating the TOTAL INCENTIVE variable.

The elasticity of the TOTAL INCENTIVE variable calculated at the means is 1.18, meaning that a one percent increase in the incentives offered to landowners is expected to bring about a 1.18 percent increase in acres retired. Our elasticity estimate is close to the elasticities calculated by Parks and Kramer (1993) and Konyar and Osborn (1990) of 0.961 and 0.322 respectively, calculated using actual enrollment rates. In comparison to the elasticity of rental payments of 5.46 calculated by Parks and Schorr also using actual enrollment rates in the CRP is significantly higher than the elasticity calculated in this analysis. Interestingly, our elasticity result of 1.18 is in the same range of elasticity's calculated by Lynch et. al. (2002) of 1.1 to 1.4 estimated using hypothetical survey responses to a riparian buffer program.

The second variant of the original model is estimated by eliminating the GIS analysis done to calculate number of eligible acres and the improved estimate of the annual incentive offered. The ELIGIBLE variable is replaced by the TOTAL LAND variable, which accounts for the amount of agricultural land in each county. The ELIGIBLE variable was calculated using GIS data, while the TOTAL LAND variable was obtained from the Census of Agriculture. Similarly, the annual incentive portion of the TOTAL INCENTIVE variable is calculated based solely on the average soil rental rate from the contracts that have signed, rather than the more accurate estimate calculated using GIS data.

The results of the model support the hypothesis that GIS data were vital to the analysis. Relying only on the amount of agricultural land in a county means that differences like watershed boundaries and the quantity of rivers and streams in a county are left out of the model. This omission has negative impacts on the entire model as evidenced by the fact that the TOTAL INCENTIVE and CRP variables are no longer significant at the 95 percent level. Since a major objective of this paper is to evaluate the relationship between incentives and enrollment, the fact that the TOTAL INCENTIVE variable is no longer significant in this variation of the model indicates that GIS data were essential. In addition, the TOTAL LAND variable is not significant at the 95 percent level, indicating that the amount of agricultural land in a county alone does not do as good a job of explaining enrollment rates as the GIS estimated amount of eligible land.

Conclusions

Understanding the factors that determine enrollment rates in a land retirement program is important to policy makers who seek to achieve a specified level of acreage enrollment at the minimum cost. Policy makers are not able to affect many of the factors that affect enrollment rates, such as the level of development pressure and the amount of farm income. Yet, factors such as the level of incentives offered to farmers can be controlled by policy makers. Knowing the relationship between all of the factors that affect enrollment would thus allow policy makers to better set the incentive rates such that the acreage goals are achieved.

Our analysis clearly demonstrates that the level of payments offered to landowners impacts the amount of land that is retired at the county level. Both the annual incentive variable in the original model and the total incentive variable in model variation one were positive and significant. Responsiveness to incentive rates allows for greater targeting of environmentally sensitive areas, where the conventional CRP does not enroll enough land to safeguard drinking water sources, or restore important wildlife habitats.

In addition, the results of the model suggest that counties that have a high degree of development pressure, high levels of irrigated cropland and many acres enrolled in the conventional CRP, will have a more difficult time enrolling landowners in CREP. Such results support intuitive arguments based on comparisons of opportunity costs.

This paper also demonstrates the importance of improved measurement of eligible acreage in the study area. To our knowledge, very little effort is currently made in estimating how much land is actually available to be enrolled in the various land retirement programs. Using a Geographic Information System, policy makers can make extremely accurate assessments of how many acres are available to be enrolled in each county which, along with the fact that eligible acreage is the most significant variable in explaining the acreage enrolled, would likely enhance the cost-effectiveness of the program. Targeting eligible acreage via a GIS could also facilitate the targeting of outreach activities to farms that contain the greatest amounts of eligible acreage.

Future research on enrollment rates in land retirement programs is crucial for improving the predictive power of such analyses. While this paper is a first attempt to explain enrollment rates in a riparian buffer program at the county level, future research will hopefully help to lend support to the results. In addition, there are other conservation practices within CREP beyond just riparian buffers. Similar analyses using a spatial approach to estimating eligible acreage could be performed for programs such as filter strips, grassed waterways and wetland restoration.

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