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Abstract

We use data from a Maryland farm survey and a selectivity model of whether cost share funding was awarded and coverage achieved with those practices to investigate adverse selection in conservation cost sharing. The estimated parameters suggest that cost share funds appear to have been directed preferentially toward farmers who exerted substantially less conservation effort than average after receiving cost share funds, so that cost share awards increased coverage by less than should have been expected. The voluntary nature of the program seems to have been at least partially responsible: Factors that made farmers more likely to apply for cost sharing also made them more likely to exert less than average conservation effort. Agency award allocation criteria may also have played a role. Agency award criteria also seem to have been flawed on environmental grounds, since cost sharing has not been directed preferentially toward water quality problems despite a stated government intention to use of cost sharing to protection water quality in the Chesapeake Bay from nutrients and sediment from agriculture.

Resumen

Este trabajo analiza la existencia de selección adversa en programas que subsidian la adopción de prácticas de conservación en Maryland. El modelo usado incluye un sistema de dos ecuaciones: la primera modela el mecanismo de selección en la asignación del subsidio; la segunda modela la proporción de la granja que se encuentra bajo la práctica de conservación. Los resultados de la estimación sugieren que los subsidios parecen haber sido asignados preferentemente a agricultores que mostraron una propensión *ex post* a implementar medidas de conservación menor al promedio. Esta selección adversa ha provocado que el impacto de los programas de conservación bajo estudio haya sido menor al esperado. El hecho que la participación en estos programas sea voluntaria parece ser una de las razones que explican estos efectos: factores que incentivan la participación de los agricultores también reducen su propensión a implementar medidas de conservación a mayor escala en sus granjas. Adicionalmente, los criterios de asignación por parte de la agencia encargada de distribuir los subsidios parecen no haber ponderado adecuadamente factores ambientales relativos a las granjas, en particular aquellos relacionados con la reducción del impacto de actividades productivas sobre la calidad de los cuerpos de agua superficiales. Ello, a pesar de la intención explícita del gobierno estatal de usar los subsidios de conservación para reducir el flujo de nutrientes y sedimentos hacia la Bahía de Chesapeake.

Introduction

The 2002 Farm Security and Rural Investment Act envisages a dramatic expansion of subsidies to promote conservation, especially measures undertaken on working farmland. The Act authorizes an immediate doubling of federal cost sharing for the installation of conservation practices under the Environmental Quality Investment Program (EQIP) as the first step toward a sixfold increase in funding by 2007. The Act also introduces a new Conservation Security Program (CSP) that offers both cost sharing and annual rental payments to farmers willing to implement conservation measures as part of their production operations. Beginning in fiscal year 2005, Congress appropriated $202 million for the CSP and plans to spend roughly the same amount annually for the subsequent seven years.

This growth in the importance of agricultural conservation programs, in particular, those subsidizing conservation on working farmland, is likely to continue. Subsidies for conservation measures are "green" under the General Agreement on Tariffs and Trade (GATT) and are thus exempt from current limits on farm support payments. Also, environmental concerns, which have assumed increasing importance in Congressional coalition-building, have exerted growing pressure to reorient farm subsidy programs toward conservation and environmental protection.

To date, however, there has been relatively little examination of how well existing programs function. However, previous theoretical and empirical studies have suggested that the effects of voluntary participation and problems of administration might limit the efficacy of cost sharing as a means of promoting conservation on working farm land. Malik and Shoemaker (1993) modeled incentives for the adoption of a single discrete conservation practice using the land-quality-based technology adoption model of Caswell and Zilberman (1986) and Lichtenberg (1989). They showed that many of the farmers applying for cost sharing could be those for whom adoption of a conservation technology would be profitable even without subsidies of any kind. In such cases, cost sharing is a pure transfer that accomplishes nothing in the way of additional conservation effort. Using a similar framework, Lichtenberg (2004a) pointed out that cost sharing could actually worsen environmental problems by making it profitable for farmers to expand production onto land that would otherwise be unprofitable to cultivate. Empirical studies of farmers' adoption of conservation measures by Cooper (1997) and Lichtenberg (2004b) suggest that many farmers may be willing to adopt conservation practices without subsidies, which implies that the scope for this form of adverse selection may be substantial.

A few empirical studies have attempted to investigate the impacts of cost sharing on measures of overall conservation effort such as estimated reductions in erosion (Ervin and Ervin 1982) and acreage served by a conservation practice (Norris and Batie 1987). These studies treat the receipt of cost share funds as exogenous, an assumption that is difficult to maintain given that participation is voluntary and that government agencies target awards, implying that the cost sharing of cost sharing funds is subject to selection effects from both sources. As is well known, estimates of the effects of cost sharing on conservation that do not take these selection effects into account are biased and inconsistent.

This paper examines the effects of cost sharing on conservation using farm-level data from Maryland, a state that presents relatively favorable conditions for such an investigation due its aggressive attempts to meet goals for water quality improvements in the Chesapeake Bay. Fostering more widespread use of conservation practices on working farm land has been the centerpiece of the state's strategy for reducing nutrient runoff from agriculture for almost 20 years. The state established its own cost sharing program —the Maryland Agricultural Cost Share Program (MACS)— which spent about $41 million over the period 1987-1996. By comparison, expenditures by federal cost sharing programs over that same period amounted to only $9 million (Lichtenberg and Bastos 1999). As a result, the number of farmers receiving cost share funds in Maryland is large enough to support statistical investigation of the determinants of cost share awards and the impact of cost sharing on conservation effort, in particular, the presence and degree of selection effects in these cost sharing programs.

Our investigation utilizes an econometric model that corrects for selection effects. We examine the effects of cost sharing on an aggregate measure of conservation effort in order to capture any spillover effects that cost sharing received for a subset of conservation practices might have on farmers' use of practices that were not cost shared. We derive full information maximum likelihood estimators of the parameters of a simultaneous equation model in order to examine the effect of cost sharing on conservation effort and determine the direction and magnitude of selection effects.

1.- Allocation of Cost Share Funds

We begin with a brief discussion of the cost share fund allocation process and the selection problems that arise in it before turning to the data and econometric model.

Cost sharing is seen as a means of counteracting underutilization of conservation practices. Some of the benefits of conservation —reductions in environmental damage due to erosion and nutrient emissions, for instance— are external (and generally costless) to farmers and thus do not necessarily enter into their farm operation decision process. As a result, the private benefits of conservation may not outweigh the costs, which include implicit costs such as reductions in operating efficiency and increases in the farmer's own labor and management time in addition to cash costs of installing and maintaining conservation practices. Lenders may also play a role by being unwilling to finance investments in conservation that promise a positive long term payoff in terms of maintenance of soil productivity, so that financial constraints may limit the use of conservation practices even when their use might be privately optimal. Cost sharing can promote greater conservation effort both by altering farmers' private benefit-cost calculations and by easing financial constraints. Government agencies that administer cost sharing programs need some assurance that any funds awarded will be put to their intended uses. Both federal and state cost sharing programs exercise oversight in much the same way. Application for cost sharing is voluntary. Applicants request funding for projects that involve the use of one or more conservation practices. Project proposals must be reviewed and approved by technicians employed by the Natural Resource Conservation Service (federal programs) or local soil conservation districts (state programs) to ensure that they are in accord with the farmer's approved conservation plan (and hence overall conservation goals in the state).[1] Once approved by a technician, project proposals are forwarded to a decision making body that makes awards from project applications subject to budget limitations. In federal programs, funding award decisions are made on a county basis by a county executive director overseen by a committee elected from and by those involved in agricultural businesses in the county. In the State of Maryland program, award decisions are made by the MACS program office in the Maryland Department of Agriculture. In both cases proposals are ranked in accordance with local priorities and awards are made on the basis of those rankings (Bastos and Lichtenberg 2001, Cattaneo 2003).

Selection problems arise in the context of cost sharing because participation is voluntary and because of the limited information and enforcement capabilities available to government agencies.

One would expect a greater propensity to apply for cost sharing on the part of farmers for whom the private net benefits of conservation practice adoption (net of transaction costs) are the greatest. Many of the farmers with high private net benefits of adoption might well engage in as much conservation activity without cost sharing as with it; which case cost sharing will have little or no effect on the overall level of conservation effort exerted. Farmers may also "game" the system by including in their proposals measures that will increase their chances of receiving an award that they do not intend to implement. Nationally, about 17% of farmers receiving EQIP funds withdrew one or more components of their proposed projects (Cattaneo 2003).

Project applications contain only information about the proposal itself; they contain no additional information about the farm operation or finances. As a result, those applications give the agencies administering cost sharing programs little ability to screen out those for whom cost sharing would make little or no difference. Those agencies have limited enforcement capabilities as well. When farmers fail to implement components of their proposed conservation project they forfeit the cost sharing associated with those components, but not the cost sharing associated with any other components they do implement. As a result, there is no penalty for false representation of intentions.

Experiences with other agricultural conservation programs raise concerns about the environmental performance of cost sharing apart from problems of adverse selection. Studies of the Conservation Reserve Program, for example, suggest that program administration can compromise environmental performance.[2] A recent Government Accounting Office (2003) report found that enforcement of the farm bill's cross-compliance provisions has been highly inconsistent due to agencies' discomfort with an enforcement role, inadequate staff resources, and weak oversight of field offices; since the same agencies administer federal conservation cost sharing programs, these findings raise concern about administration of cost sharing as well.

Programs that provide payments for the installation of conservation structures or establishment of management practices on working farmland (like EQIP and the CSP) are continuations of programs that were originally established to address problems of lost farm productivity due to erosion in the 1930s but were subsequently adapted to encompass broader environmental quality concerns (Magleby *et al*. 1995). As with any evolutionary process, vestiges of earlier goals may impair the extent and efficiency with which these new goals are met, so that non-environmental considerations may outweigh environmental ones in cost share funding award decisions. Then, too, these programs may be administrated as a means of augmenting subsidy payments to politically influential farmers, even if doing so diminishes the extent to which they meet their stated purposes.

2.- Conservation Cost Sharing in Maryland

We examine the effects of cost sharing on conservation effort using farm-level data from a survey of Maryland farm operators conducted by the Maryland Agricultural Statistics Service (MASS) in 1998. The sample of farmers was drawn from the MASS master list of farmers. Stratified random sampling was used to ensure a sufficient number of responses from commercial operations, especially larger ones. MASS provided expansion factors for deriving population estimates. The survey was administered using a computer assisted telephone survey instrument and contains information from farms across all Maryland counties.

As noted earlier, Maryland provides a favorable location for studying the effects of cost sharing. Promoting the use of conservation measures (including informational campaigns as well as cost sharing) has been the centerpiece of state and regional efforts to address nutrient emissions from agricultural sources into the Chesapeake Bay. Those efforts, combined with topographical and hydrological conditions, have resulted in relatively widespread use of conservation practices. The 1998 survey asked 487 farmers whether they used any of two dozen best management practices during the 1998 growing season (table 1). The data from this survey indicate that almost 70% of Maryland farmers used one or more of these conservation practices. They indicate further that Maryland farmers used an average of 4.6 practices. Half of the farmers using at least one conservation practice used 5 or less. About 7% used a dozen or more.

During the decade preceding the survey, both MACS and federal cost sharing programs allocated the bulk of their funds to a handful of conservation practices. Grass-and-rock-lined waterways and manure storage structures, combined, accounted for about 60% of MACS and federal cost share spending during the period 1987-1996 while sediment basins, grade stabilization, and critical area planting accounted for an additional 10 to 20% (Bastos and Lichtenberg 1999). In the mid-1990s, MACS also emphasized cover crops, which accounted for 40 to 50% of all MACS-funded projects during 1994-1996. Those agency priorities are reflected in the 1998 survey data. Over a third of all the farmers using manure storage structures in 1998 and over a quarter of all farmers using grass-and-rock-lined waterways in 1998 received cost sharing for them (Table 1). Cost sharing was also involved in 10 to 15 percent of cases involving the use of cover crops, sediment control structures (grade stabilization, sediment troughs, ponds), and various forms of critical area planting (critical area seeding, filter strips, riparian buffers, wildlife habitat, permanent vegetative cover).

The data from the 1998 survey also contain information about the farm operation, farm finance, farm topography, and human capital of the farm operator during the 1998 growing season. Information about the farm operation included 1998 acreage (owned, rented in, rented out, and total amount operated), crop acreage (corn, soybeans, small grains, vegetables, tobacco, and other crops), double cropping, and livestock numbers (cattle, poultry, hogs, sheep, horses, and other animals). Farm financial information included annual farm sales (measured categorically) and the percentage of household income earned from farming, both during 1998. Topographical information included acreage with moderate (2 to 8 %) and steep (over 8%) slopes operated during 1998. Human capital information included the age of the farm operator at the time the survey was administered, education, measured categorically in terms of formal schooling, and experience, measured as years managing a farm.

For each of the conservation practices included in the survey, farmers were asked how much acreage was served by each applicable practice used in 1998, whether they had ever received cost-sharing for each practice, and, if so, the latest calendar year they had received cost-sharing funds.

The survey also included information about potential water quality effects of each farm operation. Each respondent was asked whether there was a body of water on the land operated in 1998 and, if so, the type of water body (pond, stream, wetland, the Chesapeake Bay). Farmers who did not have a water body on-farm were asked the type of the nearest water body and the distance to that water body. The responses indicated that close to three quarters of Maryland farms have some kind of water body on site (Table 2). Overall, the average distance to the nearest water body (including farms with water bodies on or adjacent to them) was less than a mile (Table 2).

To ensure sufficient sample size, we restricted our analysis to practices used in cropping operations that were eligible for cost sharing and farms that had cropping operations. The practices included in the analysis were contour farming, stripcropping, cover crops, reduced tillage, grade stabilization, grass-and-rock-lined waterways, terraces, diversions, sediment troughs, buffers (critical area seeding, filter strips, and riparian buffers considered as a single practice), and vegetative cover (permanent vegetative cover and wildlife habitat considered as a single practice). Nutrient management practices were excluded because they were not eligible for cost sharing. Practices used only in livestock production (manure storage structures, stream fencing) were excluded because they were applicable to a small number of operations. Only farms reporting positive acreage of one or more crops (including hay) were included in the analysis. Maryland farmers used an average of nearly 3 of these practices (Table 2).

We used the responses to the question about receipt of cost share funding for individual practices to construct an aggregate indicator of cost share funding awards. If a farm operator reported having received cost sharing for at least one conservation practice during the most recent four-year period (1995 through 1998 inclusively), this indicator was given a value of one. If the farm operator reported not having received cost sharing for any conservation practices during that period, the indicator was set to zero. Elimination of farms without cropping operations, combined with non-responses to the cost sharing questions, reduced the number of usable observations to 342.

The acreage served by these 11 crop-oriented conservation practices in 1998 was used as and indicator of the size and scope of conservation projects, hence overall conservation effort. Acreage served was first aggregated across practices and then normalized by dividing by the total amount of land operated to obtain a measure of the scope or coverage of conservation measures used. We refer to this ratio of acreage served to acreage operated hereafter as "coverage". It may exceed one in the case of overlapping coverage, when farmers report that the total acreage operated was served by more than one practice. It can also be interpreted as the average number of practices used per acre operated. The (weighted) sample average was 0.86 (Table 2).

Data on the attributes of the farm operation, human capital of the farm operator, topography, and potential water quality effects were used to model both determinants of cost share funding awards and conservation effort. Table 2 provides summary statistics of these variables.

3.- Model Specification and Estimation

We estimate the impact of cost sharing on conservation effort using the following model. Let S_j^* be the amount of cost share funding awarded to a farmer who has chosen to apply for it and S_j be an indicator taking on a value of one if cost share funding was awarded ($S_j^* > 0$) and zero otherwise. We measure conservation effort z_j^* as the coverage provided by the conservation practices used (i.e., the ratio of total acreage served by those practices to total acreage operated). Let z_j^* denote conservation coverage on farmer i's operation. We assume that $S_j^*$and z_j^* are linear functions of a set of explanatory variables and a normally distributed white noise error term:

$$\begin{aligned} S_j^* &= \boldsymbol{X_{1j}\beta_1} + \varepsilon_{1j} \\ z_j^* &= \boldsymbol{X_{2j}[\beta_2 + \eta\, S_j]} + \varepsilon_{2j} \end{aligned} \qquad (1)$$

where $\varepsilon \sim \mathbf{N(0,}\Sigma\mathbf{)}$ has a bivariate normal distribution with covariance matrix

$$\Sigma = \begin{pmatrix} 1 & \sigma_{12} \\ \sigma_{12} & \sigma_2^2 \end{pmatrix} = \begin{pmatrix} 1 & \rho\sigma \\ \rho\sigma & \sigma^2 \end{pmatrix}$$

and $\mathbf{X_{1j}}$ and $\mathbf{X_{2j}}$ are vectors of exogenous farm operator and operation characteristics. The second term on the right hand side of the conservation effort equation accounts for possible interactions between conservation effort and cost share funding. The coefficients η measure how cost share funding alters farmers' conservation effort. The model is a form of switching regression model in which the receipt of cost sharing affects the observed determinants of conservation effort but not the (unobserved) random influences.

Neither S_j^* nor z_j^* are observed fully. For cost share funding awards, we observe only the discrete indicator S_j. As noted above, roughly 30% of

Maryland farmers reported using no conservation practices, hence coverage are appropriately treated as censored. We observe either only when the desired amount is positive, so that the actual amount z_j equals the desired amount z_j*; otherwise we observe only $z_j = 0$. The log-likelihood function is:

$$\ln L = \sum_{\{j:S_j=z_j=0\}} w_j \ln \Phi_2\left(-X_{1j}\beta_1, -\frac{X_{2j}\beta_2}{\sigma}, \rho\right) + \sum_{\{j:S_j=0, z_j^*\geq 0\}} w_i \left[\ln\left[\frac{1}{\sigma}\phi\left(\frac{\varepsilon_{2j}}{\sigma}\right)\right] + \ln \Phi_1\left(-\frac{X_{1j}\beta_1 + \rho\frac{\varepsilon_{2j}}{\sigma}}{\sqrt{(1-\rho^2}}\right)\right] +$$

$$\sum_{\{i:S_j=1, z_j^*\geq 0\}} w_i \left[\ln\left[\frac{1}{\sigma}\phi\left(\frac{\varepsilon_{2j}}{\sigma}\right)\right] + \ln \Phi_1\left(\frac{X_{1j}\beta_1 + \rho\frac{\varepsilon_{2j}}{\sigma}}{\sqrt{(1-\rho^2}}\right)\right]$$

where w_j is the expansion factor for observation j, ϕ is the univariate normal density, and Φ_i is an i-variate normal cumulative distribution. The likelihood function has three components, corresponding to: (1) farmers who did not receive cost sharing and did not exert any conservation effort ($S_j = z_j = 0$); (2) farmers who did not receive cost sharing but did exert positive conservation effort ($S_j = 0$, $z_j^* = z_j > 0$); and (3) farmers who received cost sharing and thus necessarily exerted conservation effort ($S_j = 1$, $z_j^* = z_j > 0$).

We estimated the parameters of this model (β,η,Σ) via maximum likelihood using MATLAB.[3]

3.1.- Selection, Cost Sharing, and Conservation Effort

We are interested primarily in (1) the effects of cost sharing on conservation effort and (2) the presence and direction of selection effects. Regarding the former, we are interested in both the expected effect of cost sharing on conservation effort (as measured by coverage) and its actual effects. Regarding the latter, we are interested in the efficiency with which cost share funds are targeted. We are interested secondarily in the criteria and farm characteristics that seem to be associated with cost share funding awards and with conservation effort.

The expected effect of cost sharing on conservation effort exerted by a randomly selected Maryland farmer equals the difference $E\{z_j|S_j=1\}$-$E\{z_j|S_j=0\}$. Expressions for these expectations follow.

$$\begin{aligned} E\left[z_j \mid S_j = 1\right] &= \Pr\left[z_j = 0 \mid S_j = 1\right] \times E\left[z_j \mid z_j^* \leq 0, S_j = 1\right] + \Pr\left[z_j > 0 \mid S_j = 1\right] \times E\left[z_j \mid z_j^* > 0, S_j = 1\right] \\ &= \Pr\left[z_j > 0 \mid S_j = 1\right] \times \left(X_{2j}\left(\beta_2 + \eta\right) + E\left[\varepsilon_{2j} \mid \varepsilon_{2j} > -X_{2j}\left(\beta_2 + \eta\right), \varepsilon_{1j} > -X_{1j}\beta_1\right]\right) \end{aligned}$$

The expectations can be calculated using the results in Rosenbaum (1961). The conditional probabilities are given by,

$$\Pr\left[z_j>0\,|\,S_j=1\right]=\begin{cases}\dfrac{\Phi_2\left(X_{1j}\beta_1,\dfrac{X_{2j}(\beta_2+\eta)}{\sigma},\rho\right)}{\Phi_1\left(X_{1j}\beta_1\right)} & \text{if current observed } z_j\big|_{S_j=0}=0\\ 1 & \text{if current observed } z_j\big|_{S_j=0}>0\end{cases}$$

Farmers with positive conservation effort in the absence of cost share funding are assumed to exert positive conservation effort in the event of a cost share funding award , so that $\Pr\left[z_j>0\,|\,S_j=1\right]=1$. The same probability for those farmers who exert no conservation effort in the absence of cost share funding is less than 1 because there is a positive probability that those farmers might decline an award. After some algebra and simplification, we have

$$E\left[z_j\,|\,S_j=1\right]=\begin{cases}\dfrac{1}{\Phi_1\left(X_{1j}\beta_1\right)}\left\{\Phi_2\left(X_{1j}\beta_1,\dfrac{X_{2j}(\beta_2+\eta)}{\sigma},\rho\right)X_{2j}(\beta_2+\eta)+\sigma\phi\left(\dfrac{X_{2j}(\beta_2+\eta)}{\sigma}\right)\Phi\left(-\dfrac{X_{1j}\beta_1-\rho\dfrac{X_{2j}(\beta_2+\eta)}{\sigma}}{\sqrt{1-\rho^2}}\right)+\rho\sigma\phi\left(X_{1j}\beta_1\right)\Phi\left(-\dfrac{\dfrac{X_{2j}(\beta_2+\eta)}{\sigma}-\rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right)\right\} & \text{if } z_j\big|_{S_j=0}=0\\ X_{2j}(\beta_2+\eta)+\dfrac{\sigma\phi\left(\dfrac{X_{2j}(\beta_2+\eta)}{\sigma}\right)}{\Phi_2\left(X_{1j}\beta_1,\dfrac{X_{2j}(\beta_2+\eta)}{\sigma},\rho\right)}\Phi\left(-\dfrac{X_{1j}\beta_1-\rho\dfrac{X_{2j}(\beta_2+\eta)}{\sigma}}{\sqrt{1-\rho^2}}\right)+\rho\sigma\dfrac{\phi\left(X_{1j}\beta_1\right)}{\Phi_2\left(X_{1j}\beta_1,\dfrac{X_{2j}(\beta_2+\eta)}{\sigma},\rho\right)}\Phi\left(-\dfrac{\dfrac{X_{2j}(\beta_2+\eta)}{\sigma}-\rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right) & \text{if } z_j\big|_{S_j=0}=0\end{cases} \tag{2}$$

Analogously,

$$\begin{aligned}E\left[z_j\,|\,S_j=0\right]&=\Pr\left[z_j=0\,|\,S_j=0\right]\times E\left[z_j\,|\,z_j^*\le 0,S_j=0\right]+\Pr\left[z_j>0\,|\,S_j=0\right]\times E\left[z_j\,|\,z_j^*>0,S_j=0\right]\\&=\Pr\left[z_j>0\,|\,S_j=0\right]\times\left(X_{2j}\beta_2+E\left[\varepsilon_{2j}\,|\,\varepsilon_{2j}>-X_{2j}\beta_2,\varepsilon_{1j}\le -X_{1j}\beta_1\right]\right)\end{aligned}$$

$$\begin{aligned}&\frac{\Phi_2\left(-X_{1j}\beta_1,\dfrac{X_{2j}\beta_2}{\sigma},-\rho\right)}{\Phi_1\left(-X_{1j}\beta_1\right)}\left\{X_{2j}\beta_2+\frac{\sigma\phi\left(\dfrac{X_{2j}\beta_2}{\sigma}\right)}{\Phi_2\left(-X_{1j}\beta_1,\dfrac{X_{2j}\beta_2}{\sigma},-\rho\right)}\Phi\left(-\frac{X_{1j}\beta_1-\rho\dfrac{X_{2j}\beta_2}{\sigma}}{\sqrt{1-\rho^2}}\right)-\rho\sigma\frac{\phi\left(X_{1j}\beta_1\right)}{\Phi_2\left(-X_{1j}\beta_1,\dfrac{X_{2j}\beta_2}{\sigma},-\rho\right)}\Phi\left(-\frac{\dfrac{X_{2j}\beta_2}{\sigma}-\rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right)\right\}\\&=\frac{1}{\Phi_1\left(-X_{1j}\beta_1\right)}\left\{\Phi_2\left(-X_{1j}\beta_1,\frac{X_{2j}\beta_2}{\sigma},-\rho\right)X_{2i}\beta_2+\sigma\phi\left(\frac{X_{2i}\beta_2}{\sigma}\right)\Phi\left(-\frac{X_{1j}\beta_1-\rho\dfrac{X_{2j}\beta_2}{\sigma}}{\sqrt{1-\rho^2}}\right)-\rho\sigma\phi\left(X_{1j}\beta_1\right)\Phi\left(-\frac{\dfrac{X_{2j}\beta_2}{\sigma}-\rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right)\right\}\end{aligned} \tag{3}$$

We used the (weighted) sample average of the difference $E\{z_j|S_j=1\}-E\{z_j|S_j=0\}$ to estimate the expected effect of cost sharing on conservation effort exerted by a randomly selected Maryland farmer.

To estimate the actual effects that cost sharing has had on conservation effort in Maryland, we followed Maddala (1983) and distinguished three cases. For those receiving cost sharing, the incremental effect of the cost share award on conservation effort equals observed effort less expected effort conditional on not having received cost share funds, $z_j - E\{z_j|S_j=0\}$. For those not receiving cost sharing but exerting some conservation effort, the incremental effect of cost sharing would have had equals expected effort conditional on the receipt of cost share funds less observed effort, $E\{z_j|S_j=1\} - z_j$. For those not receiving cost share funds and exerting no conservation effort, the incremental effect cost sharing would have had equals expected effort conditional on the receipt of cost share funds, $E\{z_j|S_j=1\}$.

We used the (weighted) sample average of the effect of cost sharing in the first of these three cases to estimate the effect of cost sharing on the conservation effort exerted by a farmer selected randomly from the group that received cost sharing. We used the combined (weighted) sample averages of the effect of cost sharing in the second and third of these three cases to estimate the effect cost sharing would have had on conservation effort by a farmer selected randomly from the group that did not receive cost sharing.

We used the difference between the two estimates to examine the efficiency with which cost share funds were allocated. This difference gives the expected change in conservation effort caused by reallocating cost share funding from a farmer currently receiving it to a farmer not currently receiving it. A positive difference indicates that cost share funding induced greater additional conservation effort as awarded. A negative difference indicates that such a reallocation of cost share funding would result in greater conservation effort, suggesting that cost share funds were not allocated efficiently.

Further information about the presence and direction of selection effects and the efficiency with which cost share funds were targeted can be obtained from the estimated covariance coefficient $\rho\sigma$ and from a comparison of the coefficients of independent variables included in both the cost share and coverage equations.

The information provided by the covariance term can be seen by examining equations (2) and (3). The second terms on the right-hand side of these equations are simply the upward correction on the expected value of z_i due to the censoring of z_i^*. The third terms on the right hand side of these equations indicate possible selection effects due to farmer characteristics we do not observe[4], as can be seen by examining formally the effect of the program on those being awarded cost sharing,

$$z_i - E\left[z_i \mid S_1 = 0\right] = z_i - \frac{\Phi_2\left(-X_{1j}\beta_1, \frac{X_{2j}\beta_2}{\sigma}, -\rho\right)}{\Phi_1\left(-X_{1j}\beta_1\right)} X_{2i}\beta_2 - \sigma\phi\left(\frac{X_{2i}\beta_2}{\sigma}\right)\frac{\Phi\left(-\frac{X_{1j}\beta_1 - \rho\frac{X_{2j}\beta_2}{\sigma}}{\sqrt{1-\rho^2}}\right)}{\Phi_1\left(-X_{1j}\beta_1\right)} + \rho\sigma\phi\left(X_{1j}\beta_1\right)\frac{\Phi\left(-\frac{\frac{X_{2j}\beta_2}{\sigma} - \rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right)}{\Phi_1\left(-X_{1j}\beta_1\right)}.$$

A positive covariance coefficient indicates a positive correlation between unobserved factors influencing both cost share awards and conservation effort, which suggests that cost share awards were made preferentially to those with a greater propensity to invest in conservation. In other words, a positive covariance term indicates that targeting of cost share awards resulted in greater than average increases in conservation effort. The same logic suggests that a negative correlation coefficient indicates that targeting of cost share awards resulted in less than average increases in conservation effort.

That a negative covariance term indicates poor targeting of cost share awards can be seen further from the expected effect of cost sharing on conservation effort,

$$E\left[z_i \mid S_1 = 1\right] - E\left[z_i \mid S_i = 0\right] = \left[\frac{\Phi_2\left(X_{1j}\beta_1, \frac{X_{2j}\left(\beta_2+\eta\right)}{\sigma}, \rho\right)}{\Phi_1\left(X_{1j}\beta_1\right)} - \frac{\Phi_2\left(-X_{1j}\beta_1, \frac{X_{2j}\beta_2}{\sigma}, -\rho\right)}{\Phi_1\left(-X_{1j}\beta_1\right)}\right] X_{2j}\beta_2 + \frac{\Phi_2\left(X_{1j}\beta_1, \frac{X_{2j}\left(\beta_2+\eta\right)}{\sigma}, \rho\right)}{\Phi_1\left(X_{1j}\beta_1\right)} X_{2j}\eta$$

$$+\sigma\left[\phi\left(\frac{X_{2j}\left(\beta_2+\eta\right)}{\sigma}\right)\frac{\Phi\left(-\frac{X_{1j}\beta_1 - \rho\frac{X_{2j}\left(\beta_2+\eta\right)}{\sigma}}{\sqrt{1-\rho^2}}\right)}{\Phi_1\left(X_{1j}\beta_1\right)} - \phi\left(\frac{X_{2i}\beta_2}{\sigma}\right)\frac{\Phi\left(-\frac{X_{1j}\beta_1 - \rho\frac{X_{2j}\beta_2}{\sigma}}{\sqrt{1-\rho^2}}\right)}{\Phi_1\left(-X_{1j}\beta_1\right)}\right] + \rho\sigma\left[\phi\left(X_{1j}\beta_1\right)\frac{\Phi\left(-\frac{\frac{X_{2j}\left(\beta_2+\eta\right)}{\sigma} - \rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right)}{\Phi_1\left(X_{1j}\beta_1\right)} + \phi\left(X_{1j}\beta_1\right)\frac{\Phi\left(-\frac{\frac{X_{2j}\beta_2}{\sigma} - \rho X_{1j}\beta_1}{\sqrt{1-\rho^2}}\right)}{\Phi_1\left(-X_{1j}\beta_1\right)}\right]$$

Since both components of the last term in square brackets are positive, a negative covariance term indicates unambiguously that cost share awards resulted in lower than average increases in conservation effort. Thus, a negative covariance term is evidence that improved targeted could improve the efficacy of cost share funding.

Additional (heuristic) evidence regarding the efficacy with which cost sharing funds were targeted can be obtained by comparing the signs of observed independent variables influencing both cost share awards and conservation effort. The coefficients of an independent variable present in both equations having the same sign is an indication of cost share awards being made preferentially to those engaging in greater than average conservation effort. Opposite signs on the coefficients of an independent variable present in both equations indicates that cost share awards were made preferentially to those engaging in less than average conservation effort.

3.2.- Other Independent Variables

The independent variables included in the cost share award equation were indicators of proximity to water bodies, topography, human capital, farm size, presence of livestock operations, and regional dummies. The equation for coverage included most of the same variables (the regional dummies and indicator of proximity to the Chesapeake Bay were excluded).

Indicators of environmental quality effects are of obvious interest given the use of cost sharing as an instrument for addressing water quality problems in the Chesapeake Bay. Characteristics of the farm operation indicating potential effects of conservation on environmental quality include the share of land with moderate and steep slopes and the farm's proximity to surface water bodies. Information on both should be included in project applications and hence available to government agencies administering cost share programs.

As noted above, the survey data included information on whether a surface water body was present on or adjacent to each farm and, if not, the distance to the nearest surface water body. Because of the prominence of the Chesapeake Bay in environmental policy in Maryland, an indicator of whether the farm was adjacent to the Bay was included in the cost share award model. If farmers' conservation investment decisions are driven by farm profitability considerations alone, proximity to surface water should have little or no influence on cost share application decisions, suggesting that the coefficients of these variables in the cost share equation should reflect government agency decision criteria alone. If water quality protection is among those criteria, then farms with water bodies on or next to them should be more likely to be awarded cost share funding while farms located farther away from water should be less likely to be awarded cost share funding. We thus hypothesize that the probability of a cost share funding award should be higher when water bodies are present on the farm (especially farms adjacent to the Bay) and decreasing in distance to the nearest water body.

Threats to productivity and the environment from erosion and nutrient runoff are greater on more steeply sloped land. One would expect agencies administering cost share programs to award more funding to projects involving more steeply sloped land in order to protect both the environment and farm productivity. One would also expect farmers to have greater incentives to invest in conservation (and hence apply for cost sharing) on more steeply sloped land. We therefore hypothesize that the likelihood of a cost share funding award should be increasing in the shares of land with moderate and steep slopes. Conservation effort should be increasing in these variables as well.

Farm size can have a number of different effects on cost share awards. It is possible that conservation projects exhibit economies of size and/or scope, in which case farmers operating larger acreage will have a greater incentive to apply for cost sharing and government agencies will be more likely to award cost share funding because economics of size and scope increase the marginal environmental benefits obtained per dollar of cost sharing awarded. Farmers operating larger acreage are likely to be more familiar with farm programs and thus more used to dealing with government officials and paperwork, suggesting lower transaction costs and thus a greater likelihood of applying for cost sharing. Finally, farmers operating larger acreage may receive more favorable treatment due to political influence. All of these considerations suggest that larger farms should be more likely to receive cost share funding. If conservation projects exhibit economies of size and scope, they should exert greater conservation effort as well.[5]

The human capital variables used in the cost share award and conservation effort models were operator age and education. Education was represented by a dummy variable taking on a value of 1 if the respondent had formal schooling above and beyond high school (e.g., technical school, undergraduate, and graduate training) and 0 otherwise. None of this information is provided to administrative bodies making cost share funding awards decisions; none of it seems relevant to those decisions, either. As a result, the coefficients of these three variables in the cost share equation should reflect only determinants of farmers' decisions. It is widely believed that older farmers tend to invest less due to shorter time horizons and, possibly, resistance to change. If they tend to invest less, they should also be less likely to apply for cost sharing. We therefore hypothesize that the likelihood of a cost share funding award and conservation effort should be decreasing in farmer age. The costs of implementing conservation practices and the transaction costs involved in applying for cost sharing should be decreasing in education, suggesting that farmers with more education should be more likely to apply for cost sharing and hence that the likelihood of a cost share award should be increasing in this variable.

The cost share award and conservation effort models also included indicators of the presence of dairy, other cattle, and poultry operations. This information is provided to the administrative bodies in project proposals. Livestock production has been implicated as a major source of nutrient emissions into the Chesapeake Bay, giving administrative agencies a reason to target them in making cost share awards. Also, there may be economies or diseconomies of scope between livestock operations and the use of crop-oriented conservation practices, so that livestock production might influence desired coverage and, indirectly, a farmer's propensity to apply for cost share funding. Since it seems likely that the sizes of livestock operations might be determined simultaneously with conservation effort and cost share awards, we included only discrete indicators of whether livestock operations were present (on the assumption that the latter is not determined simultaneously with conservation effort). Farmers raising dairy cattle in particular should be more likely to apply for (and hence receive) cost sharing due to lower transaction costs (from greater familiarity with government programs), provided that there are no substantial diseconomies of scope between dairy production and crop-oriented conservation. Dairy operations in Maryland tend to be located in areas with rolling terrain that are more susceptible to erosion, where conservation generates positive returns by protecting long run land productivity. We thus expect these operations to exert greater conservation effort—again, provided that there are no substantial diseconomies of scope present.

The share of operated land rented was also included in the model. There is no apparent reason for administrative bodies to concern themselves with land ownership, so the coefficient of the share of land rented variable should reflect only farmers' incentives. Farmers are widely believed to have less incentive to invest in conservation on rented land since long run returns accrue to the landlord, not the tenant. By this logic, farmers who rent a larger share of the land they operate should be less likely to apply for cost sharing and should exert less conservation effort.

Finally, we included in the cost sharing model categorical variables indicating the region in which the farm was located (Southern Maryland, the Upper Eastern Shore, the Lower Eastern Shore, and Central Maryland) to capture the effects of differences in the mix of agricultural activities, the importance of agriculture in the local economy, and conservation technicians and other agricultural officials. The Upper and Lower Eastern Shore and Central Maryland are the main agricultural areas in the state. The Upper Shore specializes in corn and soybean production, the Lower Shore in poultry. Central Maryland specializes in dairy; it was omitted from the analysis.

4.- Estimation Results

The estimated parameters of the simultaneous equation system, their asymptotic standard errors, and their estimated marginal effects (along with associated asymptotic standard errors) are shown in Table 3.

4.1.- Selection Effects

The presence and direction of selection effects are given by the covariance term σ_{12}. It is negative and significantly different from zero, indicating preferential awards of cost share funds made to farmers likely to exert less than average conservation effort. The magnitude of this coefficient is easier to assess if it is transformed into a correlation coefficients, ρ = -0.85, which is relatively large. The estimated covariance coefficient suggests that state and federal agencies administering cost sharing in Maryland have not been able to target cost share awards efficiently. Specifically, cost share funding appears not to have been directed to farmers who would exert the highest conservation effort upon award. Instead, farmers exerting less than average conservation effort were significantly more likely to be awarded cost share funding.

Since participation in the cost share program is voluntary, this adverse selection could have occurred in the application process, the award allocation process, or both. Our data do not allow us to distinguish definitively between these alternative explanations. However, the estimated coefficients of variables included in the cost share award and coverage equations suggest that the application process was at least partially responsible. Only two variables (aside from the regional dummies) had coefficients significantly different from zero in the cost share award equation: the dummy indicating post-high school education and total land operated. As discussed above, the coefficient of education is an indicator of the farmer's incentives while the coefficient of farm size combines both farmer and agency incentives. The coefficients of both variables were positive in the cost share award equation and negative (albeit not significantly different from zero) in the coverage equation, indicating that farmers' voluntary participation choices were at least one source of adverse selection.

4.2.- Impact of Cost Sharing on Conservation Effort

The expected increase in conservation effort due to a cost share award was statistically and economically significant. Receipt of cost share funding increased expected coverage by 0.40 (with a standard error of 0.16), amounting to a 47 percent increase over the average of 0.86.

As the preceding discussion of selection effects suggests, however, the actual performance of cost sharing has been less than should have been expected. Cost share awards made to those who received funding increased coverage by an estimated average of 0.23 (with a standard error of 0.08). Reallocation of cost share funds to farmers who were not awarded cost sharing would have increased coverage by an estimated average of 0.56 (with a standard deviation of 0.16). Thus, reallocation of cost share funds would have resulted in increased conservation effort more than twice as great (on average) as achieved by actual cost share awards. Thus, while cost sharing in Maryland appears to have been resulted in increased conservation effort, it also appears to have achieved smaller increases than would have been possible even from awards made at random.

4.3.- Determinants of Cost Share Awards

The likelihood of receiving cost sharing was systematically associated with only a handful of factors, most notably farm size (total acreage operated) and education. Farmers operating larger acreage were significantly more likely to be awarded cost share funding. This effect was quite small, however: each additional acre operated increased the probability of being awarded funding by only 0.01 percentage points (Table 3). Thus, acreage operated did not play an economically significant role in determining cost share awards.

The effect of education was more substantial: Farmers with formal schooling above the high school level were 9.8 percentage points more likely to be awarded cost sharing. As hypothesized above, this coefficient likely reflects the presence of transaction costs.

Perhaps most surprisingly, operations that presumably pose greater environmental quality risks —those adjacent to the Bay, those closer to water bodies, and those with larger shares of moderate and steeply sloped land— were not more likely to be awarded cost sharing. The coefficient of distance to the nearest water body was negative but not statistically significant. Moreover, each additional mile of distance to the nearest water body decreased the likelihood of receiving cost share funds by less than a percentage point (an estimated marginal effect that was not significantly different from zero). Despite stated concerns over water quality in the Chesapeake Bay, farms adjacent to the Bay were 8.8 percentage points less likely to receive cost share funding.

The coefficients of the regional dummies indicate that farmers in Southern Maryland and the Lower Eastern Shore were less likely to receive cost share funding than farmers in Central Maryland (the omitted category) or the Upper Eastern Shore. Thus, cost sharing for these eleven crop-oriented conservation practices seems to have been directed toward the primary crop-producing areas of the state.

Cost sharing of the crop-oriented conservation practices included in this analysis was not directed preferentially toward dairy or poultry operations. Most poultry operations are located on the Lower Eastern Shore, hence these two variables are highly collinear. A Wald test indicated that the sum of the coefficients of these two variables was not significantly different from zero (the test statistic was 0.052 with 1 degree of freedom).

4.4.- Other Determinants of Conservation Effort

In addition to cost sharing, coverage was influenced by the share of land with moderate slopes (2 to 8%), the presence of a poultry operation, and distance to the nearest water body.

Farms with larger shares of moderately sloped land had greater coverage and used a larger number of practices regardless of whether they received cost share funds. These effects were small in magnitude even though they were statistically significant: A 1 percentage point increase in the share of moderately sloped land increased coverage by 0.015 for farmers who received cost sharing and by 0.009 for farmers who did not receive cost sharing, respective increases of only 1.7 and 1.0% over the average of 0.86.

Receipt of cost share funding did seem to influence the effect of proximity to surface water on conservation effort. Farmers with a surface water body on or adjacent to their operations who did <u>not</u> receive cost share funding had significantly <u>less</u> coverage than those without surface water bodies on or adjacent to their operations. In contrast, the incremental effect of having a surface water body on or adjacent to the operation for those receiving cost sharing was positive but not significantly different from zero, indicating that farmers with a surface water body on or adjacent to their operations who <u>did</u> receive cost share funding had <u>no less</u> coverage than those without surface water bodies on or adjacent to their operations. Thus, cost sharing seems to have mitigated to some extent what appears to be neglect of environmental concerns on the part of farmers—even though concerns like proximity to surface water did not seem to have played a role in targeting of cost share awards.

The effect of the presence of livestock operations on coverage also differed qualitatively for those who did and did not receive cost sharing. Farms with poultry operations who did not receive cost sharing had significantly and substantially lower coverage: The presence of a poultry operation reduced coverage by 0.57 or 67% relative to the average, suggesting significant diseconomies of scope between poultry production and crop-oriented conservation effort. In contrast, the presence of a dairy operation or other cattle operation had no significant effect on coverage.

Conclusions

Subsidies for conservation on working farmland have assumed a new importance in farm policy, a situation likely to last given the political strength of environmentalists and limitations on farm subsidies imposed by GATT. Yet there has been little examination of how well existing conservation subsidies for working farmland (primarily cost sharing of conservation projects) result in improvements in environmental quality. Implementation of the Conservation Reserve Program, the one environmentally-oriented program that has been studied to some degree, has been shown to have been skewed away from its stated environmental goals in favor of augmenting transfer payments to politically influential farmers.

A major potential problem for conservation cost sharing is cost share funding may be provided for projects that would have been profitable even without subsidization. When awards are made in this way, cost sharing accomplishes little or no improvement in environmental quality; by diverting funds from projects that would only become profitable with cost sharing, this form of adverse selection can be seen as leading to lower environmental quality relative to what could have been achieved.

We conduct an empirical study using data from a Maryland farm survey. We develop a selectivity model of whether cost share funding was awarded and and the coverage achieved with those practices (a measure of conservation effort). We estimate the parameters of the model using full information maximum likelihood taking into account censoring of conservation effort in addition to the discrete nature of the cost share funding indicator.

The estimated parameters suggest that adverse selection has been a significant problem in cost share programs in Maryland. Cost share funds appear to have been directed preferentially toward farmers who exerted substantially less conservation effort than average after receiving cost share funds, so that cost share awards increased coverage by less than should have been expected. The voluntary nature of the program seems to have been at least partially responsible: Factors that made farmers more likely to apply for cost sharing also made them more likely to exert less than average conservation effort. Agency award allocation criteria may also have played a role.

Agency award criteria also seem to have been flawed on environmental grounds. The estimation results suggest that cost sharing has not been directed preferentially toward water quality problems. Cost sharing has been the centerpiece of Maryland's efforts to protect water quality in the Chesapeake Bay from nutrients and sediment from agriculture. Yet neither proximity to water bodies nor high slopes appeared to be determinants of cost share funding decisions. Moreover, farms adjacent to the Bay were less likely to receive cost share funds. These results are in accord with those of studies of other agricultural conservation programs like the CRP and conservation compliance provisions of the farm bill and suggest that further reorientation of staff at the local level may be needed.

Footnotes

[1] Technicians can and do require revisions to the proposal, including changes in the kinds of conservation measures used and in the ways that those conservation measures are implemented. The changes demanded by technicians can increase project expense substantially, for example, by requiring more extensive conservation measures, more expensive conservation practices, or the use of approved contractors for installation (rather than letting farmers do their own installation)

[2] Simulations by Reichelderfer and Boggess (1988), Ribaudo (1989), Babcock *et al*. (1997), and Feather and Hellerstein (1997) examined CRP signups during the late 1980s, which still account for the bulk of acreage enrolled in the program. They found that CRP signups in those years were skewed toward the High Plains, where farmers were especially politically influential, where the farm sector was especially hard hit by the financial crisis of the time (suggesting that a substantial share of land enrolled might have been idled anyway), and where environmental benefits of land diversion were generally low. Simulations conducted by Babcock *et al*. (1997) and by Feather, Hellerstein, and Hansen (1999) indicate that these distortions were reduced, but not eliminated by a subsequent change in the criterion for selecting land for CRP enrollment from reductions in erosion to an environmental benefits index that measured broader changes in environmental quality.

[3] We tested for heteroscedasticity by extending the Lagrange multiplier procedure of Harvey (1976) to a 2-equation system involving dichotomous and censored dependent variables. We tested specifically for heteroscedasticity of a general multiplicative type $\sigma_i = exp(-\mathbf{Z}\boldsymbol{a})$ in the two equations simultaneously, where $\mathbf{Z}$ is a set of exogenous variables ($\mathbf{Z} = \mathbf{X}_1$ in the cost share equation and $\mathbf{Z} = \mathbf{X}_2$ in the coverage equation). It was not possible to reject the null hypothesis of homoscedasticity (the χ^2 test statistic was 3.512 with 24 degress of freedom).

[4] It is generally the case, of course, that the agency allocating cost share funds observes some characteristics of the farm operation and/or proposed conservation projects that we do not. The covariance term captures the effects of these factors as well.

[5] The data set included information on annual sales, reported categorically and hence represented by a set of dummy variables. Annual farm sales can represent financial condition as well as size of operation. One might expect farmers with higher annual sales to be likely to have greater borrowing capacity and thus be likely to invest more in conservation. They might also be expected to have more management expertise and thus lower transaction costs, suggesting a greater propensity to apply for cost sharing. The annual sales indicators were dropped from both the cost share award and coverage equations after likelihood ratio tests indicated that they were jointly not significantly different from zero.

Table 1
Cost Sharing and Use of Conservation Practices in Maryland, 1998

Conservation Practice	***Proportion of Maryland Farmers***		
	Using the Practice and Receiving Cost Sharing	*Using the Practice Without Receiving Cost Sharing*	*Not Using the Practice*
Critical area seeding	*0.013*	*0.270*	*0.717*
Filter strips	*0.032*	*0.300*	*0.668*
Riparian buffer(s)	*0.009*	*0.190*	*0.801*
Contour farming	*0.014*	*0.200*	*0.786*
Strip cropping	*0.005*	*0.270*	*0.725*
Cover crop	*0.053*	*0.330*	*0.617*
Minimum till or no till	*0.027*	*0.450*	*0.523*
Grade stabilization	*0.002*	*0.150*	*0.848*
Grass/rock-lined waterway	*0.076*	*0.220*	*0.704*
Terraces	*0.002*	*0.050*	*0.948*
Diversions	*0.019*	*0.090*	*0.891*
Sediment troughs	*0.003*	*0.060*	*0.937*
Manure storage structure/lagoon	*0.053*	*0.100*	*0.847*
Permanent vegetative cover	*0.008*	*0.310*	*0.682*
Wildlife habitat	*0.025*	*0.280*	*0.695*
Stream protection	*0.018*	*0.190*	*0.792*
Pre-plant soil testing	*0.009*	*0.490*	*0.501*
Pre-seeding nitrogen testing	*0.002*	*0.170*	*0.828*
Manure crediting	*0.002*	*0.190*	*0.808*
Split fertilizer application	*0.001*	*0.380*	*0.619*
Manure incorporation	*0.001*	*0.270*	*0.729*
Fertilizer incorporation	*0.008*	*0.360*	*0.632*
Manure composting	*0.010*	*0.150*	*0.840*
Dead bird composting	*0.004*	*0.070*	*0.926*

Table 2
Descriptive Statistics of the Variables Used in the Econometric Model

VARIABLE DESCRIPTION	MEAN	STANDARD DEVIATION
Cost share funding received for at least one practice in the period 1995-1998	0.0986	0.2981
Ratio of total acreage served by conservation practices to total acreage operated	0.8554	1.2524
Age of the farmer in 1998	58.999	12.139
Age of the farmer in the most recent year cost share funding was received	58.894	12.161
Farmer has college education or higher or has attended to technical school	0.3429	0.4747
Percentage of highly sloped land in the total acreage operated (slope > 8%)	0.0815	0.1723
Percentage of moderately sloped land in the total acreage operated (slope 2-8%)	0.3034	0.3321
Share of total operated land that was rented in	0.1871	0.3063
Total acreage operated	191.97	288.727
Poultry operation: flock size greater than 25 chickens (yes = 1)	0.0725	0.2593
Dairy operation: dairy herd greater than 10 milk cows (yes = 1)	0.1458	0.3529
Other cattle operation: at least 1 non-dairy cow (yes = 1)	0.6014	0.4896
Farm is adjacent to the Chesapeake Bay (yes = 1)	0.0448	0.2069
Distance to the nearest water body (miles)	0.8260	3.2576
Farm has or is adjacent to a water body (yes=1)	0.7633	0.42506
The farm is in Western or Central Marylanda	0.5862	0.3844
The farm is in the Upper Eastern Shoreb	0.161	0.3678
The farm is in Southern Marylandc	0.1154	0.3195
The farm is in the Lower Eastern Shored	0.1372	0.3441

Table 3
Estimated Parameters of the Cost Share Award and Conservation Effort Models

Independent Variable	***Dependent Variable***		
	Cost Sharing Awarded	*Coverage*	
		Base Coefficient	*Interacted with Cost Sharing*
Constant	*-0.8641 (0.6864)*	*1.2882** (0.4705)*	*1.1706 (1.7646)*
Age in Year Cost Sharing Last Received	*-0.0054 (0.0100)*		
Age in 1998		*-0.0058 (0.0066)*	*0.0087 (0.0273)*
Post-High School Education	*0.5377* (0.2136)*	*-0.1234 (0.1631)*	*-0.4079 (0.4235)*
Percentage of Highly Sloped Land in Operation	*0.1181 (0.5306)*	*0.0149 (0.4490)*	*0.3511 (1.3208)*
Percentage of Moderately Sloped Land in Operation	*-0.0380 (0.3048)*	*1.2099** (0.2331)*	*0.8839 (0.6757)*
Share of Operated Land Rented	*-0.5268 (0.3889)*	*0.3600 (0.2787)*	*1.3907 (0.8246)*
Total Land Operated	*0.0008** (0.0002)*	*-0.0005 (0.0003)*	*-0.0007 (0.0005)*
Poultry Raised (Yes = 1)	*0.8153 (0.4976)*	*-1.1732** (0.3607)*	*-0.1950 (0.5769)*
Dairy Operation (Yes = 1)	*0.0322 (0.2919)*	*0.4331 (0.2325)*	*-0.9142 (0.5769)*
Other Cattle (Yes = 1)	*-0.3422 (0.2337)*	*-0.0392 (0.1661)*	*-0.1007 (0.4985)*
Farm Borders Chesapeake Bay	*0.7563 (0.5820)*		
Distance to Nearest Water Body	*-0.0818 (0.0470)*		
Farm has or is adjacent to a water body (yes=1)		*-0.9305** (0.1752)*	*1.2075* (0.6125)*
Southern Maryland	*-0.8140 (0.5027)*		
Upper Eastern Shore	*0.5173* (0.2480)*		
Lower Eastern Shore	*-0.7397 (0.5563)*		
$\sigma 2$		*1.7123 (0.0592)*	
$\sigma 12$		*-1.1093 (0.0249)*	

** Significantly different from zero at a 1% significance level.
* Significantly different from zero at a 5% significance level.

Table 4
Expected Marginal Effects of Independent Variables[a]

Independent Variable	Change in:		
		Coverage	
	Probability of Cost Share Award	Without Cost Sharing	With Cost Sharing
Age in 1998		-0.0051 (0.0044)	-0.0018 (0.3422)
Age in Year Cost Sharing Last Received	-0.0009 (0.0017)		
Post-High School Education	0.0982* (0.0403)	-0.0293 (0.1113)	-0.0147 (0.2657)
Percentage of Highly Sloped Land in Operation	0.0201 (0.0904)	0.0285 (0.2923)	0.3369 (1.1364)
Percentage of Moderately Sloped Land in Operation	-0.0065 (0.0519)	0.8508** (0.1504)	0.1642* (0.6443)
Share of Operated Land Rented	-0.0897 (0.0664)	0.1639 (0.1855)	0.8835 (0.5660)
Total Land Operated	0.0001** (0.00004)	-0.0002 (0.0002)	-0.0003 (0.3818)
Poultry Raised (Yes = 1)	0.1902 (0.1409)	-0.5721** (0.1813)	-0.3884 (0.3934)
Dairy Operation (Yes = 1)	0.0056 (0.0508)	0.3205 (0.1696)	-0.3039 (0.3265)
Other Cattle (Yes = 1)	-0.0610 (0.0428)	-0.0561 (0.1139)	-0.3254 (0.3281)
Farm Borders Chesapeake Bay	-0.0885* (0.0420)		
Distance to Nearest Water Body (If None on Farm)	-0.0139 (0.0082)		
Farm has or is adjacent to a water body (yes=1)		-0.6868** (0.1500)	0.2293 (0.4009)
Southern Maryland	-0.1017** (0.0387)		
Upper Eastern Shore	0.1076 (0.0627)		
Lower Eastern Shore	-0.0950* (0.0481)		

[a] Standard errors were estimated by the delta method
** Significantly different from zero at a 1% significance level.
* Significantly different from zero at a 5% significance level.

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