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Landowner Decision Making about Riparian Buffers

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ABSTRACT

A two-stage model is used to examine a landowner's decision to use riparian buffers. First, the farmer chooses whether to continue farming or to sell the land for development. If the farmer continues farming, then he or she must decide whether or not to plant a buffer. If the farmer plants a buffer, he or she must choose its type: trees or grass. Simulations of a representative farmer determine the parameters and parameter values that affect each decision. The farmer chooses to plant a buffer unless the net crop price is high or the land rental rate is low. The choice of buffer type is affected by crop price, farm size, relative incentive payments, relative cost share rates, and amount of deer damage.

Key Words: *Agricultural land-use, Conservation Reserve Enhancement Program, environmental policy, land-use, riparian buffers.*

Targeting important and environmentally sensitive land, the U.S. Department of Agriculture (USDA) introduced in Maryland in 1997 an enhanced version of the Conservation Reserve Program (CRP), the Conservation Reserve Enhancement Program (CREP). This new, voluntary incentive program seeks to use riparian or stream-side buffers to improve water quality and enhance wildlife habitat in one of the most productive watersheds in the world, the Chesapeake Bay. In the United States, private landowners possess 60 percent of the land nationwide, and so understanding their decisionmaking as regards their property and conservation practices is crucial to implementing programs such as CREP. Determining under what conditions a private landowner would establish a riparian buffer, when most of the benefits would accrue to society and not to the landowner, is important in setting the program's incentives and other parameters. Would a landowner choose to plant grasses, with their shorter time horizon, rather than trees in order to maintain greater flexibility in replanting the land with crops or in selling the property? Understanding the landowner's optimization given the various parameters would also permit better targeting of program money to those areas most in need of buffers.

This paper examines how agricultural landowners in Maryland are likely to respond to changes in program parameters in the new Conservation Reserve Enhanced Program. A discrete decision approach for participating or not participating is used, followed by the landowner's optimization of buffer type and size. A further decision is added to the model due to the length of the CREP contract and the

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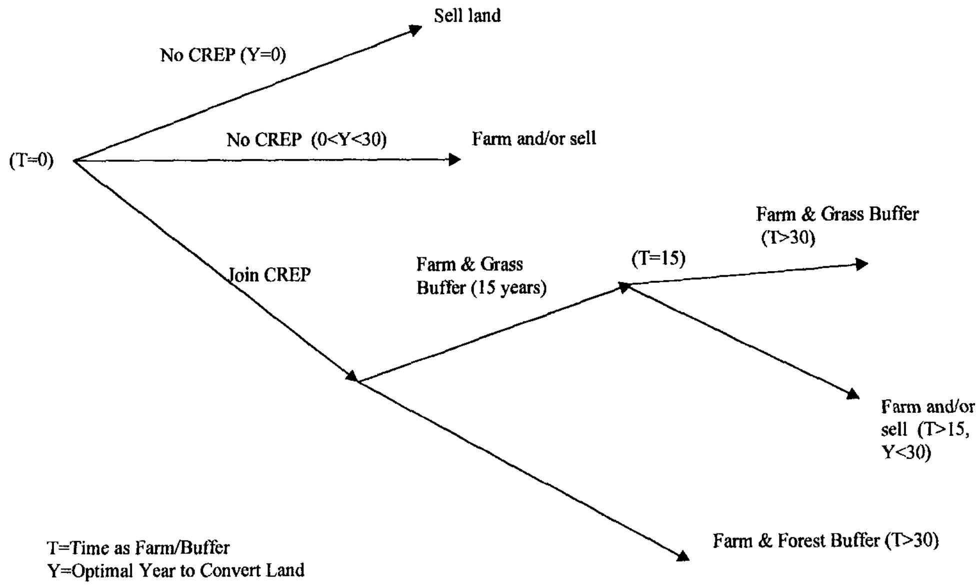

Figure 1. Decision Tree

urbanizing nature of Maryland counties. Landowners also decide whether to keep their acreage in agriculture or sell it for development. Because Maryland's CREP is the first attempt at an enhanced version of CRP, its success or failure will provide an example for other states.

Since the 1970s, more than 400 papers have been published describing various aspects of the nutrient-buffer-water interface, (Correll). Discussion of a buffer's physical and chemical processes can be found in these publications. Buffers are created with trees, shrubs, and plants. They filter, transform, and absorb agricultural nutrient runoff to improve water quality, removing 50–85 percent of the nitrogen and phosphorus as well as other agricultural chemicals from the water before it enters the stream. Few of these papers examine the landowner's incentives or disincentives for planting these vegetative buffers.

Different approaches have been used to examine landowner adoption behavior for other conservation practices. Using survey data, several authors have examined the determinants of farmers removing land from production in exchange for incentive payments. Konyar and Osborn use a discrete-choice approach to predict participation in CRP, which provides rental payments that are based on farmers' bids to retire cropland. Using regional data for the entire U.S., they found that farmers' age, farm size, land value, erosion rate, tenure system (rental or ownership), percentage of income from farming, and expected net returns all influenced the probability of participation. Hagan found that gross income from farming and percentage of net income from farming were important differences between participants and nonparticipants in the Maryland Buffer Incentive Program (BIP). This program offered a one-time $300-per-acre grant to landowners who established riparian forest buffers on their property. Almost 50 percent of the participants earned less than $1000 per year from farming. Participants also tended to be younger, have more education, and have fewer years of farm experience.

Using a contingent valuation approach, Gasson and Potter found that longer-term conservation practices needed higher rental payments. They also found that while larger growers said they would commit more acres to conservation practices than smaller growers, the actual number of acres committed was a smaller percentage of their total acreage. In a 1997 workshop about buffer adoption organized by three of Maryland's Eastern Shore

Tributary Strategy Teams, landowners expressed concerns about losing productive cropland, the increased difficulty of maneuvering farm equipment, the presumed increased of the deer population (which in turn would lead to increased predation along with concurrent decreases in yield), and the money and time required to establish and maintain the buffers.

Our model also incorporates the landowner's decision to sell or not to sell the land, to incorporate landowner expectations about the potential for development. Previous work by Hansen and Schwartz found that enrollment behavior in the California Williamson Act, a 20-year-contract preferential taxation assessment program, was not independent of the landowner's development expectations. In fact, the authors conclude that landowners' expectations about their ability to achieve an exceptionally favorable sale within the time period were overly optimistic. Landowners in Maryland may also have overly optimistic expectations. In the Chesapeake Bay region there are currently potentially significant financial returns to selling farmland for development, given the increased demand for residential property. Population in the Chesapeake Bay watershed grew 26 percent from 1970 to 1994. In 1985, about 4.0 million acres of the Chesapeake watershed were urban or suburban. This number is projected to increase to about 5.4 million acres by 2000, an increase of 35 percent over the 1985 acreage (Chesapeake Bay Program). Therefore, landowners in suburbanizing areas must consider whether they would prefer to retain their land without any constraints—constraints such as would be imposed by a CREP contract—in order to be able to take advantage of an optimal sales opportunity if one should appear.

Adoption of conservation behavior is often a two-stage process. While many previous papers have focused solely on the decision of whether or not to participate in a conservation program, this paper examines both the decision of whether to participate and the width and type of buffer chosen. In addition, the analysis allows for the opportunity cost of the lost agricultural income and the lost option to make the most profitable sale if the parcel restricted by a CREP contract cannot be sold at the optimal date. Understanding the landowner's incentive structure in an urbanizing environment with increasing land values is important.

Conservation Reserve Enhanced Program (CREP)

The genesis of CREP came from USDA refocusing its Conservation Reserve Program's resources to target the most important or most environmentally sensitive lands. The program now assigns points based on environmental values to determine priority levels of applications. This objective led to the State Enhancement Program (SEP), under which states could apply for more than the usual CRP funds in order to target environmentally sensitive lands, such as the Chesapeake Bay area. As a CRP priority area, all cropland within the Chesapeake Bay area was eligible for enrollment in CREP.

In 1996, the Chesapeake Bay Executive Committee announced a goal of 2010 miles of forested riparian buffers by the year 2010. In 1997, Maryland and USDA implemented an Enhanced Conservation Reserve Program (CREP) to provide incentive payments to landowners who plant forest buffers and filter strips to decrease the amount of nutrients entering the waterways. The program seeks to enroll 100,000 acres of land, with the following specific targets: 70,000 acres of riparian buffers (grass or trees), 10,000 acres of wetlands restoration, and 20,000 acres of land with an erodibility index greater than 15. Because Maryland's program is the first attempt at an enhanced version of CRP, its success or failure will provide an example for other states.

CREP is different from CRP in four ways:

- It has continuous sign-ups whereas CRP had a sign-up period; its annual rental payments are based on soil type and county-level rents, whereas under CRP they were based on the bids farmers made during the sign-up period.
- In addition to annual rental rates, CREP provides incentive payments for conservation practices, equal to 70 percent of the rental

Table 1. Maryland Conservation Reserve Enhancement Program Active Contracts 11/97–10/98

Number of Con tracts	Total Acres Enrolled	Acres Enrolled in Grass Buffers	Acres Enrolled in Forest Buffers	Number of Applications in Progress
508	5,722	3,100	1,108	169

Farm Service Agency, 1998.

payment for land planted in tree buffers and 50 percent of the rental rate for land planted in grass buffers. In essence, farmers receive 170 percent of the annual rental rate for trees and 150 percent for grass.

- CREP does not enroll the entire farm, as does CRP, but targets stream-side areas. The average CREP contract in Maryland is for 12 acres (the 1997 average farm size was 154 acres), with buffers ranging from 35 to 150 feet wide.
- The program's final difference from the existing CRP is its easement program, which buys an easement on the riparian area to ensure the buffer will continue into perpetuity. This easement program has not yet been implemented as it is still being designed, and so is not discussed further in this paper.

Sign-ups through October 1998 for CREP contracts, which are anywhere from 10 to 15 years long, are shown in Table 1.

Model and Simulations

A two-stage model is used that takes into account the temporal aspects of the problem and examines an individual landowner's profit-maximizing decision whether to sell the land for development or to continue crop cultivation. In the first stage of the problem farmers make two discrete choices between land-use options by comparing the net present value of each. As Maryland is a rapidly urbanizing state, farmers take into account the possibility of selling their land for non-farm use immediately ($\alpha = 1$) or at some future date Y. Because of this possibility, many landowners may not want to enroll in a fixed-term CREP contract of, say, 15 years, but would rather keep the flexibility of selling their land at any time. (The contract length is assumed to be binding because of the high penalties for breaking the contract. Penalties include repayment of all rental, incentive, and cost-share payments, as well as any punitive fines imposed by USDA. No rational landowner would enter into the contract unless he or she planned to fulfill it.)

The farmer can choose among several paths, each of which affects the feasible options in the next period (Figure 1). For example, if the landowner commits to maintaining a grass buffer for 15 years, he or she is unable to sell the property in Year 8. If the agricultural land is sold and developed, it is assumed that the sale is an irreversible decision and no further decisions will be made. Although CREP contracts for trees can be 10 to 15 years, the simulation results show that the high conversion cost of taking out trees precludes the landowner from agreeing to a 15-year contract to adopt a tree buffer. So if the landowner chooses to enroll in a forest buffer, the next decision-making time period is $t = 30$. Consequently, each landowner is deciding to maximize utility by choosing α with $\alpha = 0$ if an immediate sale is not optimal.

$$(1)\quad \max_{\alpha} E(\Pi) = \alpha(SP) + (1 - \alpha)\left[\int_0^Y \Pi_2(\beta)e^{-rt}\,dt + SPe^{-rY}\right].$$

In equation (1), Y is the optimal year to sell the land; participating in CREP may constrain the possible set of Y. SP is the sales price net of conversion costs of the irreversible decision to sell the land for development. The annual rental value of keeping the land in agriculture is captured by $\Pi_2(\beta)$, where $\beta = 1$ if the farmer joins CREP, and zero otherwise.

If crop cultivation is continued the landowner then decides whether it is optimal to participate in CREP. The second decision can be modeled as:

$$(2) \quad \max_{\beta} E(\Pi_2) = (1 - \beta) \int_0^{30} \pi_t(TA) e^{-rt}\, dt + \beta \left[\int_0^{30} \{\pi_t(TA - FB - GB_t) + \pi(FB) + \pi(GB_1) + \pi(GB_2)\} e^{-rt}\, dt \right].$$

The landowner chooses $\beta = 1$ if participation in CREP increases expected profits, or chooses to stay out of the program, $\beta = 0$. Agricultural returns, π_t, depend on the number of acres planted, where TA is the total number of acres. FB, GB_1, and GB_2 are the number of acres planted in forest or grass buffers and the yield per acre, which varies each year. With respect to planting grass buffers, GB_1 and GB_2 are used to differentiate between the first 15 years and for the second 15 years. The per-acre returns, π, depend on the number of acres planted in forest and grass buffers and the rental rate given under the CREP contract, but do not vary by year.

Once a discrete choice has been made the farmers shift to the second stage, that of determining how wide a buffer and which type (grass or trees) provides the greatest net present benefits relative to planting crops. Under CREP, participants receive greater incentive payments and higher cost-share rates for forest buffers. During a workshop, however, farmers expressed a number of drawbacks they think forest buffers have (Eastern Shore Tributary Teams). In addition to increasing the number of years land is out of production and delaying the possible land sale date, farmers believe, for example, that a forest buffer will reduce the yield on the remaining acres. They think that the trees will shade the fields, make it more difficult to operate equipment, and attract more wildlife (deer), which will in turn increase predation and decrease yield (Eastern Shore Tributary Teams). Therefore, a damage function is included to incorporate potential deer-connected yield losses. Yield losses due to deer are assumed to increase with acres planted in forest buffers, $D(FB)$. The damage function can be expressed as $D(FB)$, where $(1 - D(FB))$ is the proportion of potential harvest the grower realizes. Damage is assumed to increase with additional acres of forest buffer but at a decreasing rate, ($D'(FB) > 0$; $D''(FB) < 0$). Each grower chooses the optimal buffer type and number of acres to maximize profits, trading off crop acreage and crop damage for incentive payments on the buffered acreage. All of the crops are sold in competitive markets, so the net price of the crop P is exogenous to the model. Thus, the buffer decision can be written as:

$$(3) \quad \max_{FB, GB_1, GB_2} E(\pi) = \int_0^{14} \{Pf(A)A(1 - D(FB)) + (1 + \psi)\Theta FB + (1 + \eta)\Theta GB_1\} e^{-rt}\, dt + \int_{15}^{30} \{Pf(A)A(1 - D(FB)) + (1 + \psi)\Theta FB + (1 + \eta)\Theta GB_2\} e^{-rt}\, dt - (1 - \lambda)FC_1 FB - (1 - \rho)FC_2 GB_1 + (SV \cdot FB)e^{-r30}.$$

The production function for crops, $f(A)$, gives us the per-acre yield, with A being the number of acres planted to the crop. Crop production is assumed to increase with acreage but at a decreasing rate. FB is the number of acres planted to forest buffers, with Θ as the annual rental rate and Ψ the level of the incentive payment. GB_t is the number of acres planted to grass buffers, with the same annual rental rate Θ and an incentive payment level of η. The fixed cost of installing and maintaining a buffer is FC_1 per acre for forest buffers and FC_2 for grass buffers. Fixed costs for installing the buffer occur only once, in Year 1. The cost share rates are λ for trees and ρ for grass. The trees also earn a stumpage value of SV per acre after 30 years of growth.

The comparative static results predict that farmers will increase both forest and grass buffers if rental rates increase, own-incentive payment's percentage increases, or the own cost-share rate increases. If the forest buffer's cost-share rate increases, it is ambiguous whether grass buffers will increase or decrease, and vice versa. Farmers decrease forest buffers when net crop price per bushel increases, when *r* (the discount rate) increases, or when the number of acres in crops increases. Landowners will also decrease grass buffers when net crop price increases. These results follow standard economic theory and are not surprising. The interesting questions are the different trigger levels that impact both the discrete and the continuous decisions. The simulation results are discussed below.

Simulations

Trigger points were determined where buffer type changes or where farmers decide buffers are not optimal. Interestingly, the simulations show that if a landowner decides to participate he or she will plant the entire permitted acreage in a buffer. There were no cases where the farmer decided to plant the buffer partially in trees and partially in grass. Given that trees pay more but cause damage, the hypothesis was that farmers would plant trees on some acres to get the higher payments but not on others because of the damage component. The spatial aspects of the problem which may lead to this result—i.e., landowners may decide to plant trees next to the stream and then grass next to the field to buffer their fields from the deer or from shading—were not included in the model, since doing so would require knowing whether the stream was on the edge of the field or ran down the center of the field. In addition, as acreage increased farmers needed to put a higher and higher percentage of their acreage into trees before trees were determined to be optimal. This contradicts the results obtained by Gasson and Potter. Again, the absence of any spatial element may contribute to this result.

The software program "Excel" was used to conduct simulations to determine the impact of different parameters on the decision to plant a forest buffer, a grass buffer, or no buffer. The simulations were based on a representative farm of 100 acres currently growing non-irrigated, conventional corn. Corn prices in Maryland, an important poultry-producing region, ranged from \$2.90 to \$3.60 per bushel. Using crop budget data for this region, the average price for a bushel of corn in this simulation was \$3.25. The average total cost of corn production was \$2.66 per bushel; thus, average profit per bushel was \$0.59. Assuming \$0.59 per bushel is the result of profit-maximization over fixed and variable inputs, the base net price of \$0.59 is used in the simulation.

Average corn yields in this region range from 80 to 120 bushels per acre. Yields varied in the simulation over the years of the CREP contract. To do this the random number generator in the Excel spreadsheet was used to pick each year's yield from a range of 80 to 120 bushels per acre. Maryland farmers around the state suffer losses in yield from deer browsing on crops. In 1996, nearly 92 percent of farmers indicated that they suffered deer damage. Statewide, farmers lost on average 5 to 13 percent of harvested yield, for an estimated loss of almost \$38 million (McNew and Curtis). An average yield loss of 6 percent was assumed in an exponential damage function where damage increases with the number of acres planted to a forest buffer. A grass riparian buffer was assumed to result in no additional deer damage.

Given that a maximum of 150 feet from the edge of the stream is eligible for a CREP contract, a farmer was assumed to be eligible to enroll no more than 10 percent of his or her acreage into CREP. Thus the representative farmer was constrained to enrolling a maximum of 10 acres into the buffer program. The soil rental rate in Maryland ranges by county from \$30 per acre to \$88 per acre. For the base case, an annual per-acre soil rental rate of \$70 was used. This rate of payment corresponds to soil types that would produce the range of yields mentioned above. The current incentive payment levels are 50 percent of the rental rate for grass and 70 percent for tree buffers. To install and maintain a riparian forest buffer costs approximately \$575 per acre and a grass

Table 2. Optimal Land-Use Choice Based on Land Value and Contract Length

Land Price per acre ($)	Optimal Year to Sell if unconstrained by CREP Contract	Optimal Year to Sell if constrained by CREP Contract	Optimal Land Use Choice: Agriculture Use plus:
$2,000	30+	30+	Forest Buffer for 30 years
$2,500	30+	30+	Forest Buffer for 30 years
$3,000	30+	30+	Forest Buffer for 30 years
$3,500	30+	30+	Forest Buffer for 30 years
$4,000	30+	30+	Forest Buffer for 30 years
$4,500	30+	30+	Forest Buffer for 30 years
$5,000	28	30	Forest Buffer for 30 years
$5,500	22	30	Forest Buffer for 30 years
$6,000	20	30	Forest Buffer for 30 years
$6,500	19	19	Grass Buffer for 15 years
$7,000	17	17	Grass Buffer for 15 years
$7,500	12	15	Grass Buffer for 15 years
$8,000	12	15	Grass Buffer for 15 years
$8,500	12	15	Grass Buffer for 15 years
$9,000	12	15	Grass Buffer for 15 years
$9,500	5	15	No Buffer
$10,000	5	15	No Buffer

* Based on Representative Farm: 100-Acre Corn Farm, 10 percent riparian area, Net crop price, $0.59, average yield, 100 bushels, yield loss, 6 percent, Rental rate, $70, Forest Costs, $575, Grass Costs, $400, Forest Cost-Share, 87.5 percent, Grass Cost-Share, 50 percent, Forest Incentive Payments, 70 percent, Grass Incentive Payments, 50 percent, discount rate, 4 percent, Stumpage, $800.

buffer costs $400 per acre (Memo From USDA/NRCS on Flat Rates). Farmers can receive cost-share payments for the installation of either of these buffers. The current cost-share rate for a grass buffer is 50 percent. The broader array of habitat and water quality benefits provided by a forest buffer are reflected in the higher soil rental rate bonus payment, as well as in the higher cost-share rate of 87.5 percent.

At the end of the CREP contract period a farmer can sell the trees that have been grown on a forest buffer. As mentioned previously, any farmer considering a forest buffer is going to optimize over a longer time frame of two contract periods, or 30 years. A managed 40-acre site of pine that is sold for pulpwood would return $1000 per acre at the end of 30 years. Therefore, the stumpage value of the riparian forest buffer in Year 30 is assumed to be $800 per acre (Templin Forestry). The cost of harvesting the trees from a buffer are assumed to be higher than on a 40-acre site. The farmer maximizes the present value of the profit received from the acreage left in agriculture plus the rental and bonus payments for the riparian buffer for 30 years. A discount rate of 4 percent is assumed.

These numbers were then used to simulate the discrete decisions. The optimal year to sell property was computed given an appreciation in land value of 3.5 percent a year. A range of land values from $2,000–10,000 per acre was used. Several scenarios were simulated: choose to sell immediately ($Y = 0$), choose agriculture with no buffers until the optimal year to sell ($Y > 0$), choose one 15-year contract of grass ($Y > 14$), or choose a 30-year contract of trees or a 30-year contract of grass ($Y > 29$). If the optimal year to sell the property falls before the end of the contract, the landowner decides, based on the highest present value, whether to enter the contract and constrain the date of sale or to retain the option of selling at any date.

Results

Table 2 presents the results for the decision whether to enter the program or sell one's

Table 3. Optimal Choice of Buffer/No Buffer and Buffer Type Based on Parameters

Parameters	Type of Buffer	Size of Buffer (acres)	Present Value of 30-year Income ($)	Present Value of 30-year Continuous Ag Income ($)
Base Case*	Forest	10	$115,162	$108,560
Net Crop Price < $0.65 per bushel	Forest	10	$122,960	$117,760
$0.64 < Net Price < $0.92 per bushel	Grass	10	$124,523–167,579	119,600–167,440
Net Price > $0.91 per bushel	None	0	$169,280	$169,280
Rental Rate: $55–88 per acre	Forest	10	$110,577–120,665	$108,560
Rental Rate: $48–54 per acre	Grass	10	$108,652–110,271	$108,560
Rental Rate: $30–47 per acre	None	0	$108,560	$108,560
Forest Incentive Payment: 66%	Forest	10	$114,659	$108,560
Forest Incentive Payment: 65%	Grass	10	$114,587	$108,560
Forest Cost Share: 78%	Forest	10	$114,616	$108,560
Forest cost Share: 77%	Grass	10	$114,587	$108,560
Stumpage Value: $614 per acre	Forest	10	$114,589	$108,560
Stumpage Value: $613 per acre	Grass	10	$114,587	$108,560
Acreage: 10–100 acres	Forest	1–10		
100–100,000 acres	Grass	10–10,000		
Discount Rate: 6.6%	Forest	10	$87,664	$83,545
Discount Rate: 6.7%	Grass	10	$86,838	$82,784
Damage Level: 6.6%**	Forest	10	$114,612	$108,560
Damage Level: 6.7%	Grass	10	$114,587	$108,560

* Base case is a 100-Acre Corn Farm, 10 percent riparian area, Net crop price, $0.59, average yield, 100 bushels, yield loss, 6%, Rental rate, $70, Forest Costs, $575, Grass Costs, $400, Forest Cost-Share, 87.5%, Grass Cost-Share, 50%, Forest Incentive Payments, 70%, Grass Incentive Payments, 50%, discount rate, 4%, Stumpage, $800.
** Damage percentage is based on 10 acres being placed into riparian forest buffer.

land. For land valued at $4500 per acre or less the landowner would optimize by staying in agriculture and selling in 30 years or later. For land valued at $5000 to $6000 per acre, the landowner's optimal year to sell would fall between 20–28 years, or less than the 30-year time horizon. However, the landowner would achieve a higher present value by waiting until year 30 to sell and putting in a 30-year buffer. For property valued at $6500–9000 per acre, the optimal time to sell would vary from 12 to 19 years. In this case the grower should select a 15-year buffer and then sell in Year 15 or later. When the land was valued at $9500–10,000 per acre the growers would not enter into a contract but would maintain their option to sell in the optimal year.

In the case of the second decision, to participate in the program or not participate, farmers would refrain from entering a CREP contract in only two cases: when net crop prices per bushel were very high (>$0.91) and when rental rates were very low (<$48.00). Therefore, Table 3 incorporates these results on participation in the program from the simulations as well as describing the buffer selection and size decision. In the base case simulation the farmer chooses to enroll 10 acres in riparian forest buffer for 30 years, for a total present value of profit of $115,162. This includes the profits from crops, the soil rental rate plus bonus payment, the cost-share for tree planting, and the 30-year stumpage value of the forest buffer, as well as accounting for the increase in crop damage from deer.

If the per-bushel profit for the corn crop is less than $0.65, the farmer chooses the forest buffer. When the net price is less than $0.92 but greater than $0.64, the farmer chooses the grass buffer. If the per-bushel profit for the corn crop is greater than $0.91, the farmer chooses to plant no buffer—to not enroll in CREP. Farmers would plant forest buffers if net crop prices were $1.25 per bushel or less, if deer-caused yield loss was not connected to the forest buffers.

The simulation also demonstrated that the size of the farm matters because of the negative impact of the additional deer damage to the crops. A farm of 100 acres is the largest that would install a riparian forest buffer when deer damage is a problem. A farmer with as few as 10 acres would choose to enroll 10 percent in the forest buffer program. Large farms (up to 100,000 acres in the simulation) would install the maximum 10 percent of acreage in a grass buffer. If the acreage constraint were relaxed, a farm of 150 acres would plant trees only if they were allowed to plant at least 53 acres. Similarly, a 200-acre farm would plant trees only if 103 acres were permitted. Thus as farm size increases tree buffers are planted only if the number of acres permitted is an increasing percentage of the total acreage. Options from 10 percent to 35 percent to 52 percent were simulated. Trees can be very profitable, but this profitability has to be compared to the lower yield farmers perceive will accompany tree buffers. Profitability on large farms is enhanced with a large number of trees. In such a case each additional acre of forest buffer contributes marginally less to the yield decrease; in addition, there are fewer acres left in crops to be damaged. If the model assumed that no additional deer predation would occur following the planting of the forest buffer, farms of all sizes from 1 to 10,000 acres would choose to plant the maximum number of acres permitted in forest buffers.

The simulations show that at base prices, costs, yields, and incentive levels, farmers will enroll as many acres as possible into CREP. The 10-percent acreage constraint was always binding. If allowed to, the base-case farmer would enroll all 100 acres into the riparian forest buffer program. The stumpage value of the timber would be an important determinant in deciding whether to plant trees or grass. If the stumpage value were less than $614 per acre, the farmer would plant a grass buffer instead of a forest buffer. If no additional deer damage were to occur following the planting of the forest buffer, then a farmer would plant forest, even if the stumpage value were $0.

The ratio of cost-share percentages would influence the tree-versus-grass decision. The ratio of λ (tree cost-share) to ρ (grass cost-share) would need to be greater than 1.54 for the farmer to choose a forest buffer over a grass buffer. This would correspond to a cost-share of 77 percent for trees and 50 percent for grass, relative to the current tree cost share of 87.5 percent and grass cost share of 50 percent. The soil rental rate bonus payment ratio, ψ (forest incentive) to η (grass incentive), would need to be greater than 1.3 to influence a farmer to choose trees over grass. This corresponds to a bonus incentive of 65 percent for trees and 50 percent for grass, relative to the current tree bonus of 70 percent and grass bonus of 50 percent.

Under the simulation, different annual soil rental rates would result in different riparian buffer types. A payment of $30 to $47 per acre, along with the corresponding bonus incentives (yields do not change from the base-case random pattern), would result in no riparian buffer contract. If the annual per-acre soil rental rate were between $48 and $54, a grass buffer would be installed for two 15-year contracts. If the annual per-acre soil rental rate were between $55 and $88, a riparian forest buffer would be installed for 30 years. Without deer damage, landowners would be willing to put in forest buffers when rental payments were as low as $30 per acre. Below that rate no buffer would be installed.

The choice of buffer type would not depend on small changes in the discount rate. Up to an interest rate of 6.6 percent, the landowners would still install a forest buffer. Only when the discount rate was greater than 6.7 percent would the farmer choose a grass buffer instead. The increase in crop damage caused by deer that could possibly occur when a forest buffer was installed would have an impact on the farmer's decision to install the grass buffer. The base-case damage level of 6 percent as a result of a forest buffer would not deter farmers from planting 10 percent of her acreage in trees. At a damage level of 6.7 percent, the representative farmers would switch to a grass buffer. Deer damage caused on average a 5 to 13 percent loss of harvest yield on Maryland farms (McNew and Curtis). Thus in areas with the higher loss, farmers concerned about attracting more deer would possibly not risk the possibility of lower yields that could come from a forest buffer, and instead would choose grass.

Conclusions

This simulation of a landowner's decisionmaking has revealed several results that may assist policymakers in designing voluntary conservation programs. By incorporating the decision whether to sell the land or remain in agriculture, the analysis demonstrates how important non-agricultural opportunity costs are in participation decisions. If environmentally sensitive but high-value land, such as in the Chesapeake Bay watershed, is targeted for enrollment additional incentives in addition to the soil rental rate payments based on agricultural opportunity costs may be necessary. Landowners in urbanizing areas with land sale prices per acre greater than $6500 may need higher rental rates or incentive payments to be enticed into entering the program. If the targeted areas have land values greater than $9500 per acre, much higher incentive payments would be needed to achieve enrollment objectives. Whether the environmental benefits of enrolling such high-valued agricultural land are sufficient to justify the additional expense, or whether USDA would want to incorporate non-agricultural opportunity costs into the rental payment scheme for this type of program, remains to be determined. Current CREP enrollment reflects lower participation in counties with high land values and low soil rental rates per acre.

Some policymakers have questioned whether the 20-percent difference in incentive payments between those for trees and those for grass is sufficient to induce farmers to plant trees rather than grass buffers. Farmers in the base case would choose trees over grass if the incentive payment ratio were at least 1.31. This provides some confirmation that the existing program parameters should be sufficient to encourage tree buffers. Farmers were more likely to shift buffer types from trees for 30 years to grass for 15 years as the potential land sale price and land sale date changed than when the relative incentive payments changed.

Up-front costs for adoption were important in landowner decision making. Farmers were more sensitive to the relative cost-share rates between grass and trees than to relative incentive rates. Since trees are more expensive to install and maintain, growers needed a cost-share ratio of 1.56 to select trees rather than grass. Since at this time Maryland landowners can get cost-share payments of up to 100 percent of the costs in many cases (from additional payments made by Ducks Unlimited or by the Chesapeake Bay Foundation), they should not be deterred from planting trees. This result suggests that increasing cost-share rates may be more effective than increasing rental rates. In addition, programs such as CREP may find that dollar-for-dollar signing bonuses paid up front encourage more participation than do annual rental payment increases.

Interestingly enough, the perceived damage from deer to the crops from tree buffers does not impact the decision to plant at the average yields or at the average net price in Maryland for a 100-acre farm. As acreage increases, though, the permitted percentage of acres that could be planted to buffers become a constraint to choosing tree buffers. In addition, as net crop price increases, deer damage shifts landowners to a grass buffer. At the average net price per bushel, farmers find tree buffers the optimal decision. If the net price per bushel increases by an amount ranging from $0.06 to $0.32, grass buffers are preferred because of the crop damage caused by a tree buffer. Only after the net price has increased by at least $0.33 to more than $0.91 will the landowner determine that the land is more profitable in corn instead of as a buffer. Program administrators may need to increase incentive rates in priority areas to encourage tree buffer participation when deer numbers are high and crop damage likely.

Similarly, if the annual rental rate is less than $48 per acre, landowners will not participate in the program. Only when the rental rate increases to $55 per acre will the farmer choose tree buffers. Given the available incentives, landowners in counties where land prices are less than $6000 per acre should be signing up for the program. If annual rental rates cannot be adjusted, incentive bonus payments may be necessary in counties with lower rental rates to enroll landowners.

Maryland farmers are signing up in larger numbers for grass than tree buffers (Table 1). One explanation is that they want more flexibility to sell or to convert the buffer. Or it could be that deer predation is a real concern for these landowners. The simulation results suggest that land values, rental rates, and crop prices are the three elements that affect the participation decisions. The program should be able to achieve high enrollment levels in areas with low land values and high soil rental rate. If certain areas of the Chesapeake Watershed fit these criteria and will provide environmental benefits, program money and personnel should target them. If on the other hand areas with high land values or low rental rates are desired, additional incentives such as higher annual incentive rates or signing bonuses may be needed to achieve enrollment goals. If deer predation is a concern to farmers, tree buffers may be chosen only if the relative incentive for them is sufficiently high relative to grass. For the average Maryland corn farmers, the existing relative incentive and cost-share rates should be sufficient for them to choose tree buffers over grass buffers. As the average acreage per farm increases, as it is doing on the Eastern Shore, or as rental rates decrease, as they are in Southern Maryland, the existing program parameters may result in adoption of a grass buffer or in no participation.

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