Willingness of Forest Landowners To Use Poultry Litter as Fertilizer

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The authors are assistant professor in the Department of Agricultural and Resource Economics, and natural resource specialist in Maryland Cooperative Extension, University of Maryland. This research was supported by a grant from the Maryland Department of Business and Economic Development and conducted in cooperation with the Association of Forest Industries, Inc.

Key Words: poultry litter, forest landowners, water quality, phosphorus

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Abstract

When manure nutrients exceed a county's cropland assimilative capacity, the potential for water quality problems exists. Concerns about water quality have led to the passage of the Water Quality Improvement Act in Maryland which will impact the disposal of poultry litter on cropland. Forest fertilization may be an alternative use for the litter. Forest landowners indicated their willingness to use poultry litter as a forest fertilizer under a variety of incentives. Landowners with more acres, in certain counties, and who were younger were most likely to be willingness. Surprisingly, landowners who work with foresters were not more likely to agree, suggesting that foresters may not know about the potential benefits of poultry litter application in timber growth.

I. Introduction

The U.S. has 160 counties whose livestock produce more manure phosphorous than can be used in the county, even if spread on all cropland in the county. The excess must either be exported to another county or disposed of in some other way (Kellogg et al. 2000). Sixty-four percent of operations with farm-level excess phosphorous had poultry as the dominant livestock type on the farm (Kellogg et al. 2000). When manure nutrients exceed the assimilative capacity of an entire county, the potential run-off and leaching can generate serious water quality problems. Concerns about the levels of nutrients in Maryland waterways led to the passage of the Maryland Water Quality Improvement Act of 1998, which may have significant impacts on the application of poultry litter on agricultural land. The industry needs to explore alternative disposal mechanisms that are cost-effective. To determine whether application to neighboring forest land is a possible alternative, forest landowners were surveyed about their willingness to use poultry litter as a forest fertilizer under a variety of financial incentives.

Research has examined the costs or implications of restricting poultry litter applications to agricultural land and of using alternative policies to achieve the optimal level of application (Bosch, Zhu, and Kornegay 1997; Govindasamy and Cochran 1998, 1995; Komen and Peerlings 1998; Parker 2000; Prato, Zu and Jenner 1992; Schnitkey and Miranda 1993; Xu and Prato 1993). However, to the best of our knowledge, no one has investigated the alternative of forest land application nor the forest landowners' willingness to use poultry litter.

Several papers demonstrate the benefits of forest fertilization, including the use of biosolids (Henry 1986, Edmonds and Cole 1977, Allen 1994, Allen and Lein 1998). In addition, forest

fertilization has become a more common practice, with fertilized acres climbing from 40,000 acres of pine in 1988 to 1,037,000 acres of pine in 1998 in nine southern states (NCSFNC 1998). Bush et al. (1997) found that one ton of poultry manure per acre produced the greatest response in pine growth. Using poultry litter, forest landowners may be able to increase their financial return, as well as assist neighboring poultry growers with their disposal issue. However, if increasing forest yields is not a primary concern for forest landowners, incentives beyond an increased timber yield may be needed to ensure that enough landowners are willing to provide an alternative disposal site for poultry litter. Birch (1994a, 1994b) examined landowners' objectives for owning their forest land and reports that 40 percent have forest because it was "part of the purchased parcel." Twenty-nine percent of the landowners have forest for recreational and aesthetic enjoyment. Only 3 percent of those surveyed stated that timber production is an important objective.

Background

Southeastern states from Arkansas and Louisiana to Virginia have many counties with excess phosphorus (Kellogg et al. 2000). But even some northeastern states, including the Delmarva Peninsula states, have poultry litter disposal issues. The poultry industry raises approximately 625 million chickens on the Delmarva Peninsula each year, producing more than 750,000 tons of manure (Goodman 1999). These flocks excrete 53 million pounds of manure nitrogen (N) and 22 million pounds of manure phosphorus (P) each year[1] – two nutrients that in large quantities can adversely impact water quality. Poultry farming has been identified as one of the significant sources of these

[1]This number assumes that most growers follow the feeding recommendations of the National Research Council, which – given that most growers are operating on a contract basis – is likely.

nutrients that can negatively impact the Chesapeake Bay and other water resources (College of Agriculture and Natural Resources 1997).

Owners of poultry houses traditionally have disposed of this poultry litter by spreading it onto cropland as fertilizer. In addition to there being insufficient cropland on which to use the litter, recent research has shown that soils with very high phosphorous levels may need more than sediment control to prevent phosphorus runoff from these fields. According to Coale (1999), under some farm management systems, years of application of P beyond that level necessary for optimum nutrient availability has resulted in extremely high soil P levels, which may contribute to P enrichment of field drainage water.

Maryland's General Assembly passed the Water Quality Improvement Act of 1998 to address concerns about these nutrients. This Act may curtail application of manure litter as fertilizer in certain areas (Parker 2000). Although Govindasamy and Cochran (1995) demonstrate that given certain crop prices and transportation costs, transporting poultry litter from one Arkansas region to another is feasible, this may not be the case in Maryland. The cost of poultry manure application from poultry house to field, assuming a 90-mile haul from the Lower to Upper Eastern Shore, is $21 per ton applied if 1.51 tons per acre is the rate of application (Parker 1998). The cost of transporting and spreading the 750,000 tons of manure produced in the Delmarva region would be $15.75 million if sufficient cropland were available on the Upper Eastern Shore.[2] The increased cost of poultry production that would result from higher transportation costs will negatively affect the poultry industry's profitability. Given that the economic impact of a 4 percent decline in Maryland's poultry production would result in

[2]The cost would be even greater if growers had to find available cropland even further away.

an annual loss of $74 million in economic output in the state, a $29 million loss in personal income and business profits, and a loss of 880 jobs, a decrease in the poultry industry's profitability could have serious implications for the economic health of the Delmarva agricultural industry (Musser and Mallinson 1996).

Lower Shore forest landowners, on the other hand, have not traditionally used poultry litter. Thus their land is not saturated. Eighty-five percent of 290 surveyed forest land samples had phosphorus levels that were low or very low based on the University of Maryland's index value categories (Clayville 2000). Nor are the concerns about the impact on water quality the same for forest land as for cropland, given that forest systems can filter and transform nutrients such as nitrogen and phosphorous (Palone and Todd 1997). There are almost 678,500 acres of forest land in eight counties on Maryland's Eastern Shore (Table 1). Assuming the establishment and thinning of pine plantations in any one year is approximately 13,000 acres and that the rate of application is 2 tons per acre, 20-23,000 tons of poultry litter could be applied on forest land annually (Tjaden and Garret 1999).

Model

Each forest landowner is assumed to experience benefits and costs from using poultry litter on her forest land. If a landowner perceives that the costs of using litter exceeds the benefits in terms of increased growth and profit, he or she will not employ the manure as a fertilizer. Conversely, if the benefits exceed costs, a landowner will use the manure. While exact benefits and costs are difficult to determine for each individual landowner, using a stated preference approach, a landowner's willingness or agreement to use poultry litter can be elicited. This approach is based on random utility theory,

which permits discrete choices in a utility-maximizing framework (Hanemann 1984, Hanemann and Kanninen 1996). An individual's indirect utility function can be represented by $V_i(x_i, q)$ where x_i is the personal and land characteristics of the individual i and q is the use of poultry litter; $q=0$ if poultry litter is not used (the status quo) and $q=1$ if poultry litter is used. If the landowner has chosen not to use poultry litter, his indirect utility is greater without use than with use, or $V_i(x_i, 0) > V_i(x_i, 1)$. If the landowner has chosen to use the litter, then we assume the benefits exceed the costs, or $V_i(x_i, 0) < V_i(x_i, 1)$. To increase the benefits of using poultry litter, one can provide incentives for manure use, such that $V_i(x_i, 0) < V_i(x_i, 1, C)$, where C is the monetary incentive provided when poultry litter is used. Thus an owner's willingness to use poultry litter can be altered by finding the incentive bid level that ensures $V_i(x_i, 0) < V_i(x_i, 1, C)$. If the incentive was sufficient to ensure that $V_i(x_i, 0) < V_i(x_i, 1, C)$, a landowner will respond that she agrees to use poultry litter. The incentive level offered could result in a situation where $V_i(x_i, 0) = V_i(x_i, 1, C)$, and the owner may say he does not know whether he is willing or he is indifferent to using poultry litter. Similarly, if the level of incentive results in a situation where the costs remain larger than the benefits, $V_i(x_i, 0) > V_i(x_i, 1, C)$, then a landowner would decline to use poultry litter.

Many factors will affect a landowner's indirect utility function and thus willingness to use poultry litter. Increased revenues from timber harvest due to the fertilization's impact on tree growth is expected to increase a landowner's utility. Landowners who expect to sell timber in the future will receive a monetary benefit from the increased growth thus are hypothesized to be more willing than those landowners who have no such plans. Landowners who currently have a forest management plan may find that poultry litter is another management tool for them to use to achieve their objectives. They

are expected to be more willing to use the litter than landowners without a management plan. Landowners who are operating farmland next to their forest land, i.e. have a role in the day-to-day management, rather than leasing it out or not farming it are expected to be more willing to adopt poultry litter fertilization. Those who had previously sold timber are hypothesized to be more willing to use litter since they have experience in timber sales and may better understand the benefit of increased growth. In addition, landowners who have never sold timber may own timber for objectives other than profit, such as recreation or aesthetics. Therefore, these landowners are expected to be less interested in increased profitability. We expect that a connection with a forester may increase a landowner's willingness to use fertilizer. Thus we include a variable about whether the landowner had been assisted by a forester in a previous timber sale. This connection may also decrease the transaction costs of using the poultry litter, assuming the forestry community has been educated about its use.

The timing of a previous timber sale or an expected sale may also impact a landowner's willingness. For example, if respondents are more likely to use fertilizer when reestablishing a stand of trees, one would expect that the number of years the respondent has owned the farm to impact his or her willingness. Landowners who recently purchased the land may be more likely to use poultry litter. Similarly, the timing of the previous timber sale indicates when fertilization would be useful. We expect that landowners who have sold their timber within the last 2 years and are reestablishing their stands would be more likely to agree to use poultry litter than those who sold longer ago. However, if the sale had been made more than 10 years ago, these landowners could be planning a future sale and thinking about reestablishment. They thus may be willing to consider investigating the possibility of using poultry litter in the future. The landowner's age may also affect the expected utility of poultry litter forest

fertilization. Younger landowners would be more willing to consider poultry litter use since they are more likely to benefit from the increased growth of their forest stand. Therefore, we hypothesize that landowners 60 years or older are less likely to adopt poultry litter unless they have a very strong bequest motive.

Few forest landowners have used poultry litter for forest fertilization previously. The transaction costs (time and energy) to learn about these practices may decrease a landowner's indirect utility and thus his willingness to use the litter. The transaction costs are expected to be lower per acre for forest landowners with larger stands. Therefore, we expect a higher level of willingness to consider the manure's use from landowners with more acres compared to those with 50 or fewer acres. We also expect that these larger landowners are more likely to be managing their timber for profit and thus will be more interested in the increased growth and productivity that fertilization will provide. Landowners in the Lower Shore counties of Somerset, Wicomico, and Worcester are closer to the poultry houses. Because of this proximity, these landowners may already have experience with using poultry litter on their cropland, and would have lower transaction costs to adopt poultry litter fertilization in their forest stands. These landowners are expected to be more willing to agree than those in other counties. Respondents with a college degree or higher level of education are thought to be more willing to use poultry litter than those who did not finish college.

Econometric Models

If the true willingness to use poultry litter is Y_i, given x_i, the proxies for benefits and for costs, then $Y_i = x_i$ ß+ u_i . The vector, x_i, includes personal and parcel characteristics for individual *i* (age, education, geographic location, forest practices, expectations). While an individual may know her

preferences with certainty, these preferences may contain elements that are not observable and thus an error term is included. The error is assumed to have a standard normal distribution such that $u_i \sim N(0,1)$. The true willingness, Y_i, is not observed, but the stated response of willingness on the survey, y_i, can be used.

Concerns about respondents' ability to state their true willingness have caused debate about the stated preference method. Respondents may be unable to provide their true preferences because they have had little prior experience with the item in question and thus may have difficulty assessing the costs and benefits during a single survey (Cummings et al. 1986). A person's willingness may be formed or may adjust by the new information provided by the survey itself (Gregory and Slovic 1997). Similarly, if the offered incentive is truly an optimal bid for individual *i*, then "don't know" or "indifferent" could actually be the valid answer. If the willingness question is vaguely defined, respondents also may be unable to determine their true level of willingness. Svento (1993) demonstrates that recoding "don't know" answers into the "no" category or into the "yes" category results in substantially different aggregate benefits measures for a project. Using an ordered model did not decrease the variance of the estimates but did permit the researchers to tease out the "indifference belt." To determine the extent of the interest in using poultry litter on forest land in the Eastern Shore, we want to examine how characteristics affect respondents' willingness for those who are uncertain ("don't know") as well as for those who indicated "yes." Ten percent of our sample responded with "don't know."

Therefore, two different types of econometric models are estimated. First, we estimate a binary probit under which the "don't know" responses are assumed to be "no" answers. Second, we

estimate an ordered probit where the "don't know" responses are treated as a middle category.[3] An ordered-response model (rather than a multinomial logit) is used due to the natural ordering of the discrete choices ("willing," "don't know," "unwilling").

For the binary case, the observed or stated willingness is used as the dependent variable assuming that y_i=0 if x_i ß <u_i, and y_i=1 if x_i ß >u_i. Thus the $Prob(y_i$ ' 1) ' $Prob(\mu_i$>&x_iß) ' 1&F(&x_iß), where F is the cumulative density function for µ; assuming a normal distribution (Maddala 1983), the likelihood function is:

$$L \text{ ' } \prod_{y_i \text{ ' } 0} F(\&x_i ß) \quad \prod_{y_i \text{ ' } 1} [1\&F(\&x_i ß)]$$

The log-likelihood of this function is maximized with respect to the ß.

For the order case, the stated preference is used as the dependent variable assuming that

y_i = 0 (*unwilling to accept)* if $a_{-1} < Y_i < a_0$;

y_i = 1 (*don't know*) if $a_0 < Y_i < a_1$;

y_i = 2 (*willing to accept)* if $a_1 < Y_i < a_2$;

such that $a_{-1} < a_0 < a_1 < a_2$. The a's are free parameters and bind the ranges containing the true preference, Y_i. No significance is assigned to the unit of distance between the stated responses, y_i's. We set $a_{-1} = -4$, $a_2 = +4$, and anchor a_0 at zero. Y_i is assumed to be within the jth range if $a_{j-1} < Y_i < a_j$ (j=0,1,2). The Prob($y_i = j$) is the probability that Y_i is in the j^{th} range. Let y_{ij} = 1 if Y_i is in the j^{th}

[3]We also estimated a binary probit model for which the "don't know" responses were treated as missing. The coefficient estimates under this model were qualitatively and statistically equivalent to those reported for the ordered probit model. Therefore, the estimated coefficients from this model are not reported. Since we have a large data set in the study, we could have discarded the "don't know" responses with missing data with little effect on the estimation. However, with many surveys of this type, the number of observations necessitates the use of the "don't know" responses.

range, and $y_{ij} = 0$ otherwise (Greene 1995).

The probability that an individual's response was answer j is

$Prob(y_{ij} = 1) = \Phi(a_j - x_i b) - \Phi(a_{j-1} - x_i b)$, where again Φ is the cumulative density function for the normal distribution, x_i is a vector of exogenous characteristics of individual i, and the α's and β's are coefficients to be estimated. The likelihood function is:

$L = \prod_i \prod_j [\Phi(a_j - x_i b) - \Phi(a_{j-1} - x_i b)]^{y_{ij}}$ The log likelihood is:

$\log L = \sum_i \sum_j y_{ij} \log [\Phi(a_j - x_i b) - \Phi(a_{j-1} - x_i b)]$ We used SAS version 6.12 to compute the regression estimates.

Data

In June 2000, American Forest Industries and Maryland Cooperative Extension conducted a telephone survey of 402 landowners owning 40 or more acres of forest land in eight counties on Maryland's Eastern Shore. A list of 4,000 forest landowners was generated from the Maryland Tax and Assessment Database. The survey goal was 10 percent of the landowners, or 400 completed surveys. A tele-match service was used to locate telephone numbers for these landowners, and 3,320 telephone numbers were identified. Eighty-nine individuals, or 22 percent of the number of completed surveys, refused or did not complete the survey for various reasons. In addition, 144 individuals were not eligible because they had no forest land.

Descriptive Statistics

Most respondents (59 percent) owned fewer than 50 acres of forest land, while 20 percent owned more than 100 acres. Of those with pine trees (90 percent), 37 percent stated that their pine stand made up 50 percent or less of the forest land they owned. Over one-quarter of the respondents reported that 75 to 100 percent of their forest land was in pine. Table 2 presents the means and standard deviations for the survey sample.

Ninety-three percent of survey respondents reported that they privately own their own land. Twelve percent have owned their land for five years or less, 12 percent from 6 to 10 years, 25 percent from 11 to 20 years, 15 percent for more than 20 years. Forty-two percent of the respondents currently have a forest management plan. Fifty-eight percent have sold timber from their land at some point in the past. Thirty-eight percent were assisted by a forester in the timber sale. Eleven percent have sold timber within the last two years, another 13 percent between 3 and 5 years ago, 11 percent between 6 and 10 years ago, and 22 percent more than 10 years ago. Almost half the respondents (48 percent) said they were likely to sell timber at some point in the future. Of those with agricultural land next to their timber land, 32 percent farm it themselves (owner/operator), and 43 percent lease the farmland to others. Twenty-two percent of the respondents earn 10 percent or less of their income from farming or forest management activities. Forty percent earn between 11 and 25 percent of their income from these occupations, while 10 percent earn between 26 and 50 percent, and 7 percent between 51

and 100 percent. Six percent of respondents were less than 40 years old, 38 percent were between 40 and 59 years old, and 47 percent were 60 years old or older. Over one-third of the respondents (37 percent) had finished college. Sixty-one percent of the survey respondents were male.

Results

Awareness Questions

When asked if poultry litter was an effective fertilizer for increasing growth and profit from timber sales, almost half of all respondents (49 percent) "agreed," 34 percent "did not know," and 17 percent "disagreed" (Figure 1). More than half of the respondents (54 percent) agreed that the application of poultry litter to forest land was an environmentally sound practice when done as part of a nutrient management plan, while 24 percent said they disagreed, and 22 percent either responded that they did not know or provided no answer. When asked about commercial fertilizers, more respondents said that they did not know whether fertilizers like 10-10-10 would increase tree growth (42 percent) than those who agreed that it would (39 percent). Another 19 percent said that 10-10-10 would not increase pine tree growth. This level of awareness coincides with the silvicultural practice of *not* fertilizing trees, which was established many years ago. The cost of fertilization was deemed too high for the economic return received. However, research in the forest industry has begun to demonstrate that, in certain cases, fertilization may be profitable (Albaugh et al. 1998; Allen 1994; Allen and Lein 1998; Beem et al. 1998; Moorehead 1997; and Moorehead 2000).

After eliciting awareness about these issues, the respondents were read a brief statement indicating the benefits of poultry manure in increasing pine tree growth:

"According to recent studies by the University of Maryland and other research

> universities, pine forests are well suited for the use and application of poultry manure as a fertilizer. By following a simple management plan, pine tree growth increases by 20-30 percent with no adverse environmental impacts to the forest land or watershed."

Respondents were then asked if they would be willing to use poultry litter under a range of different incentive mechanisms. Sixty-three percent of the survey respondents said they would consider a poultry litter application if offered a reduction in state income taxes (Figure 2). Sixty-four percent agreed that if Maryland provided a cost-sharing program that defrayed the application costs of poultry litter, they would consider applying it. An even greater number of respondents (67 percent) said they would consider poultry litter fertilization if a reduction in property tax was offered as an incentive. Fewer than 50 percent of respondents (49 percent) said they would agree to apply poultry litter if the incentive were a one-time payment of $20 per acre. An average of 10 percent of the respondents did not know whether they would use poultry litter under these incentive schemes.

The level of incentive provided by the different mechanisms varies. Policymakers could examine which incentive mechanism gives the highest degree of willingness for the lowest implementation cost. It is difficult, however, to determine the actual cost of implementation and the benefit to the landowner of these various mechanisms. For example, state income tax reductions depend on the level of relief provided. Given a state income tax rate of 5 percent, a $100 credit would be worth $5 and a $1000 deduction would result in $50 tax savings. A cost-share program that covered 100 percent of the cost would remove any direct cost to the landowner of using the poultry litter. If the landowner was using commercial fertilizer in a pine stand establishment, using poultry litter at no charge would save the landowner the cost of the commercial fertilizer. These savings were

estimated to be $46.14 per acre. If the landowner was not using fertilizer, then poultry litter use would benefit the landowner by increasing growth and future timber returns. The present value of a property tax reduction incentive if one assumes a 5 percent interest rate and reduction for a 20-year period would be $46.73 per acre. Conversely, the $20 per acre incentive reduces to $14.40 if the landowner is in the 28 percent income tax bracket (Lynch and Tjaden 2000b).

Unfortunately, for any robust economic analysis, the questions about willingness with the different incentive levels did not include monetary levels except in the case of the $20 per acre payment. It is impossible to know what each respondent was thinking about the value of the different incentives when indicating her willingness. Therefore, while interesting to know which type of incentives elicited the highest degree of willingness, direct comparisons between the types of incentives cannot be made. However, we do have one incentive scheme that contained a monetary value. The analysis of willingness to consider poultry litter use under this scheme provides a basis to conduct further analysis and insights into which type of forest landowners might be the most receptive. Therefore, we present this set of regression coefficients explaining an owner's willingness to consider poultry litter use when a one-time incentive of $20 per acre is provided.

Regression Results

The estimated coefficients for both the binary probit and the ordered probit explaining willingness to use poultry litter with a one-time incentive payment of $20 per acre as a function of demographic, farm, and land characteristics are found in Table 3.

In the binary model, the "don't know" responses were recoded as "no" responses. The overall fit of the model was good ($?^2 = 53.894$, $D.F.=21$). The model correctly predicted 73.6 percent of

the actual responses. Some of the estimated coefficients were consistent with our expectations. The timing of a past timber sale influenced a landowner's willingness. Those with sales between 6-10 years ago were less willing to consider poultry litter fertilization than those with a sale in the last 2 years. Younger farmers were more willing to agree than those landowners aged 60 years or older. Landowners who owned more than 200 acres were more willing to consider poultry litter use than farmers who owned 50 or fewer acres. However, landowners with 51-200 acres were not statistically different from the owners of smaller acreages. Thus our hypothesis about lower transaction costs for larger growers was not fully borne out. Only respondents who lived in Somerset County were more willing than respondents in other counties to apply poultry litter to their forest land if paid $20 an acre. Neither Worcester nor Wicomico respondents were more likely that those in the Upper Shore counties.

We have some estimated coefficients that were contrary to our hypothesis. For example, landowners who owned the land for 6-10 years were more likely to agree to consider poultry litter use than more recent owners. Those who had owned the land for more than 10 years were not statistically different from the more recent owners. Landowners with a forest management plan were *less* likely to agree to poultry litter use. This suggests that the foresters in Maryland may not be recommending fertilization of tree stands. Alternatively, Maryland landowners may be designing their forest management plans around non-growth objectives. Having sold timber in the past did not influence a landowner's willingness. In addition, those who said they were likely to sell timber in the future exhibited no difference from those who didn't plan to a future sale. Those who operated the adjacent farmland themselves were not more willing than those who leased out the land or did not farm it.

Neither gender nor education had any influence on willingness.

The ordered probit estimated coefficients were similar in most cases. The overall fit of the model was good ($?^2$ = 58.184, D.F.=21). The model correctly predicted 70.7 percent of the actual responses. The estimated coefficient for number of acres owned, for county of residence, for landownership, and for the forest management plan variables had the same sign and were statistically significant in both the binary and order probit models. The ordered probit however had a number of estimated coefficients that were statistically significant than were not significant in the binary probit case. For example, those with sales more than 10 years ago were less willing to consider poultry litter fertilization than those with a sale within the last 2 years. In sum, landowners with timber sales within the last 5 years are more likely than others to agree to use poultry litter. This supports the hypothesis that landowners are most likely to be willing when they are re-establishing their tree stand. Unlike the binary model, this analysis found that if a respondent had sold timber in the past, he was more willing to consider applying poultry manure. If a forester had assisted a respondent with a past timber sale, then the respondent was more willing to consider using the litter. Under this estimation, we also find that those respondents who are owner/operators are more likely to consider poultry manure use than those who lease out the land or do not farm it.

Conclusions

The survey and analysis reveal two separate issues. First, forest landowners may not think that fertilization is an economically efficient practice, especially if they are planning a future sale. Fewer than 40 percent of the survey respondents knew that commercial fertilizer would increase tree growth. Almost half said they were aware that poultry fertilizer could increase growth. Over half (54 percent)

thought that applying poultry manure could be an environmentally sound practice. Educational programs would be needed to explain the benefits and costs of forest fertilization to determine whether fertilization itself is an optimal or desirable practice for pine forest landowners.

Second, many forest landowners expressed willingness to consider using poultry litter. As alternative disposal options are sought for the litter, policymakers need to determine what type of incentive program is likely to shift willingness into action and which type of landowner should be targeted. Almost half of the survey respondents indicated their agreement to consider using poultry manure as fertilizer on their pine trees if offered a $20 per acre incentive payment. However, if policymakers also want to motivate those landowners who responded "do not know" or "disagree," a higher incentive payment per acre or a different type of incentive will be necessary. These results provide some preliminary information for designing such a program, although information about the other incentive mechanisms (property tax reduction, income tax reduction, and cost-share) linked to monetary levels would be useful. Policymakers also need to determine whether Maryland forest landowners seek to maximize profits from their stands or are managing them for non-monetary objectives. If profit motives are secondary for many owners, incentives to aid the nearby poultry industry and to promote environmental stewardship might appeal to them more than direct financial incentives. Increased tree growth may promote carbon sequestration, for example, thus educational programs outlining this benefit may motivate some landowners to use poultry litter.

We found that using the ordered probit model teased out additional significant coefficient estimates compared to the binary probit model. The ordered probit results indicated that timber sales will influence willingness. Those who had sold timber in the past, those who were assisted by a

forester, and those who plan to sell timber in the future are more willing to consider poultry litter application. Thus landowners with past timber sales could be targeted by an incentive program. The consistent results between the two models suggest that under the $20 per acre incentive mechanism, farmers with more than 200 acres were more likely than those with fewer than 50 acres to agree to use poultry litter. Outreach efforts could target farmers with more acreage, who are more willing to use poultry litter and may have more forest acreage on which to apply it. In addition to farmers with more acreage, landowners in Somerset and nearby Lower Shore counties should be approached first. Somerset respondents indicated a higher level of willingness to use poultry litter than respondents in other counties. Younger farmers also expressed a higher level of willingness to consider poultry manure applications than did older farmers.

Having a timber management plan decreased a landowner's willingness. Workshops to educate the forester community that assists forest landowners in designing management plans that discuss the benefits of fertilizer use and especially poultry manure on forest land may be required. Given the degree of negative publicity that nutrients and poultry litter in particular have garnered over the last few years in Maryland, it is possible that foresters are recommending that forest landowners do not fertilize their land.

Forest landowners' willingness to apply poultry litter may provide an alternative to applying it to cropland, as the Water Quality Improvement Act is implemented and nutrient management plans formulated. The proximity to poultry houses, the low phosphorus level, and nutrient uptake ability of forest stands make forest land fertilization an environmentally sound alternative. In addition, it may be more cost-effective than transporting the litter to other regions for use on cropland. Pine stands are

present in many Southeast states, many near poultry-producing regions. Thus forest fertilization may also be an option for other regions and counties generating excess phosphorous beside the Delmarva Peninsula. While a possible alternative, forests alone will not provide enough acreage for all the available manure. However, beyond being a poultry litter disposal alternative, forest fertilization may have additional benefits including increased timber growth, carbon sequestration, wildlife habitat provision, and support of the forest industry. Thus, policymakers should continue to investigate what type and level of incentives may be needed to motivate a high degree of willingness to use poultry litter on the part of forest landowners.

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Table 1. Number of Forest Acres on the Maryland Eastern Shore

County	Number of Forest Acres	Percent of Respondents
Kent	41,824	6
Queen Anne	60,805	9
Caroline	61,874	12
Talbot	42,328	7
Dorchester	125,071	15
Wicomico	104,157	19
Somerset	83,113	15
Worchester	159,298	18
Total	**678,470**	**100%**

Table 2. Means and Standard Deviation for Survey Respondents
(N=402)

Variable	Mean	Standard Deviation
Owns more than 200 acres	9.84%	0.298
Owns between 101-200 acres	21.86%	0.414
Owns between 51-100 acres	9.56%	0.294
Somerset	14.68%	0.354
Wicomico	18.91%	0.392
Worchester	17.91%	0.384
Owned land 5 or fewer years	11.96%	0.325
Owned land between 6-10 years	11.70%	0.322
Owned land between 11-20 years	24.94%	0.433
Owned land more than 20 years	51.40%	0.500
Has a forest management plan	41.86%	0.494
Has sold timber	58.44%	0.493
Forester helped sell timber	37.53%	0.485
Sold within last 2 years	11.14%	0.315
Sold between 3-5 years ago	12.66%	0.333
Sold between 6-10 years ago	10.89%	0.312
Sold more than 10 years ago	22.28%	0.417
Likely to sell timber in the future	48.45%	0.500
Owner/Operator	31.63%	0.466
Ten percent or less of income from farm/forest management	21.70%	0.413
Between 11-25 % of income	39.62%	0.490
Between 26-50 % of income	10.38%	0.305
Between 51-100 % of income	7.23%	0.259
Less than 40 years old	5.97%	0.237
Between 40 to 59 years old	38.06%	0.486
60 years or older	46.77%	0.500
Male	61.19%	0.488
College Graduate	37.37%	0.484

Table 3. Regression Estimates of Willingness of Forest Landowners to use Poultry Litter if given a Per Acre Payment of $20

	Binary Probit Model (Don't know =No)		Ordered Probit Model (Don't know =1)	
Variable	**Estimated Coefficient**	**ASE**	**Estimated Coefficient**	**ASE**
Intercept #1	-0.8359 **	0.2777	-0.7585 **	0.2608
Intercept #2	XXXX	XXXX	-0.4781 *	0.2595
Owns more than 200 acres	1.152 ***	0.3213	1.038 ***	0.3084
Owns between 101-200 acres	0.1007	0.2658	0.0962	0.2541
Owns between 51-100 acres	0.3725 *	0.194	0.2944	0.1841
Somerset	0.5401 **	0.2312	0.484 **	0.2201
Wicomico	0.2044	0.2034	0.1888	0.1926
Worchester	0.1666	0.2124	0.1164	0.201
Owned land between 6-10 years	0.6404 **	0.3168	0.6453 **	0.3016
Owned land between 10-20 years	0.3814	0.2625	0.3836	0.2477
Owned land more than 20 years	0.1292	0.251	0.1436	0.2363
Has a forest management plan	-0.6105 ***	0.1837	-0.5825 ***	0.1724
Has Sold Timber	0.4994	0.3238	0.5887 *	0.3127
Forester helped sell timber	0.2762	0.2177	0.3423 *	0.2069
Sold between 3-5 years ago	-0.1263	0.3445	-0.2135	0.3354
Sold between 6-10 years ago	-0.5716 *	0.3381	-0.7321 **	0.3272
Sold more than 10 years ago	-0.4443	0.3139	-0.6188 **	0.3043
Likely to sell timber in the future	0.1186	0.1691	0.1242	0.1599
Owner/Operator	-0.00598	0.1708	-0.0603	0.1618
Less than 40 years old	1.0532 ***	0.3472	0.9214 **	0.3286
Between 40 to 59 years old	0.4978 ***	0.1702	0.3977 **	0.161
Male	0.0141	0.1638	0.0318	0.1548
College Graduate	0.0312	0.1609	0.0396	0.1521
Log Likelihood	398.488	$?^2$=53.894, d.f.=21	560.443	$?^2$=58.184, d.f.=21

*** indicates confidence of the coefficient estimate at the 0.01 level, ** at the 0.05 level, * at the 0.10 level

Figure 1. Attitudes and Awareness of Landowners

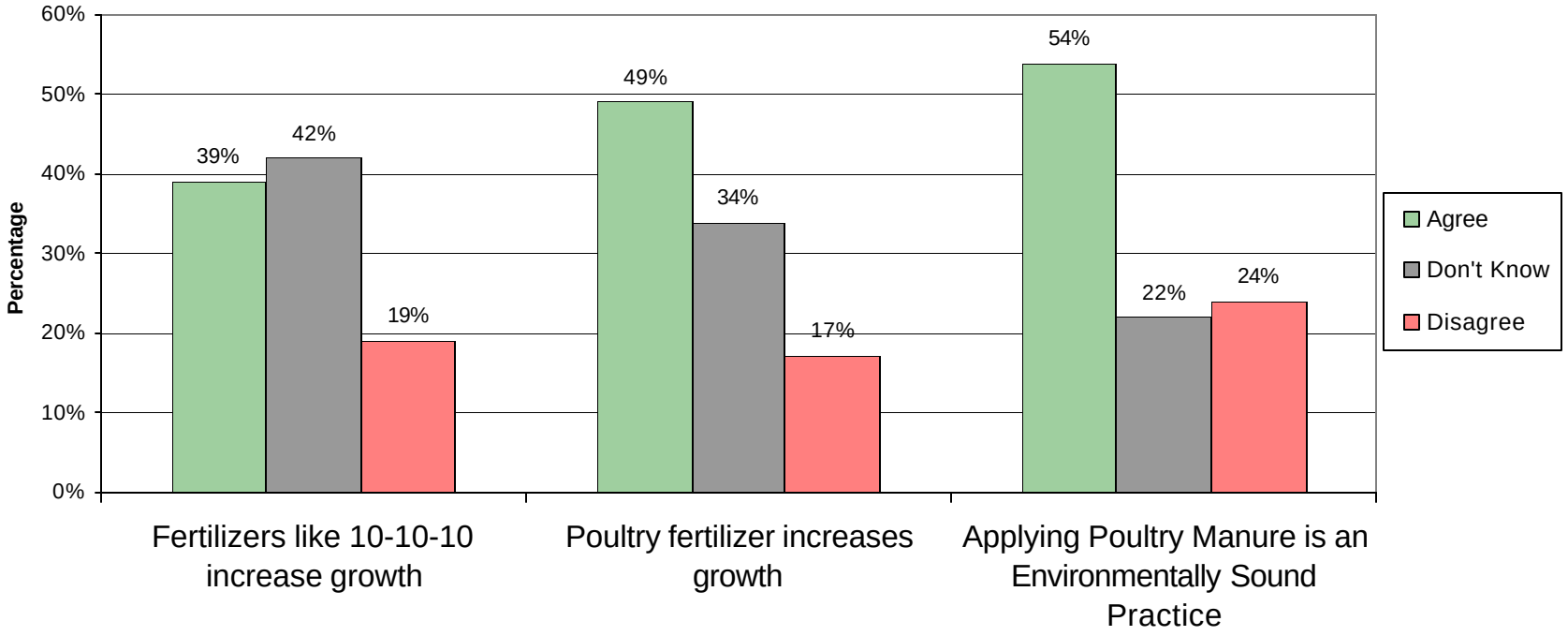

Figure 2. Landowners' Willingness to Use Poultry Litter under Different Incentives