



Assessing the Interest and Capability for Private Forest Landowner Involvement in Utilizing Poultry Litter on the Eastern Shore of Maryland

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*A Study Devised by
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1. Poultry Litter as Forest Fertilizer

by William Miles and Douglas Munro

Mr. Miles is the executive director of the Association of Forest Industries, Inc. and Dr. Munro is the president of InterGroup Services, a consulting firm.

Two facts: First, poultry farming is the largest industry on the Delmarva Peninsula (made up of nine Maryland counties, two Virginia counties and all three Delaware counties). Excess poultry manure is a serious environmental concern in the area, given the propensity for its associated nutrients to run off fields and eventually filter into Chesapeake Bay, one of Maryland's most precious natural resources.

Second, forestry is the Shore's second-largest industry, an industry constantly interested in finding means to increase timber growth.

Our concern in this project has been to ascertain if these two facts can be married. If there is too much manure nutrient material within Eastern Shore agricultural soils, what of forested soils? Are forested soils more able safely to absorb manure nutrients? If so, are forest landowners willing to use such manure to fertilize their pine stands? Answering these questions has been the primary aim of this project, generously funded by the State of Maryland's Animal Waste Technology Fund.

If the answers to these questions are yes — if forested soil *can* absorb manure nutrients and if landowners *will* apply chicken litter as fertilizer — then this project can be said significantly to have strengthened the potential for partnership between Maryland's agricultural and forestry industries in pursuit of common goals, goals that are environmentally sound and economically beneficial.

Our project has had three components: (a) a comprehensive poll of landowners' attitudes toward the application of chicken litter upon forest stands, (b) an analysis of 290 soil samples

taken from representative forested areas of the Eastern Shore and (c) a series of meetings designed to inform the community as to the project's progress.

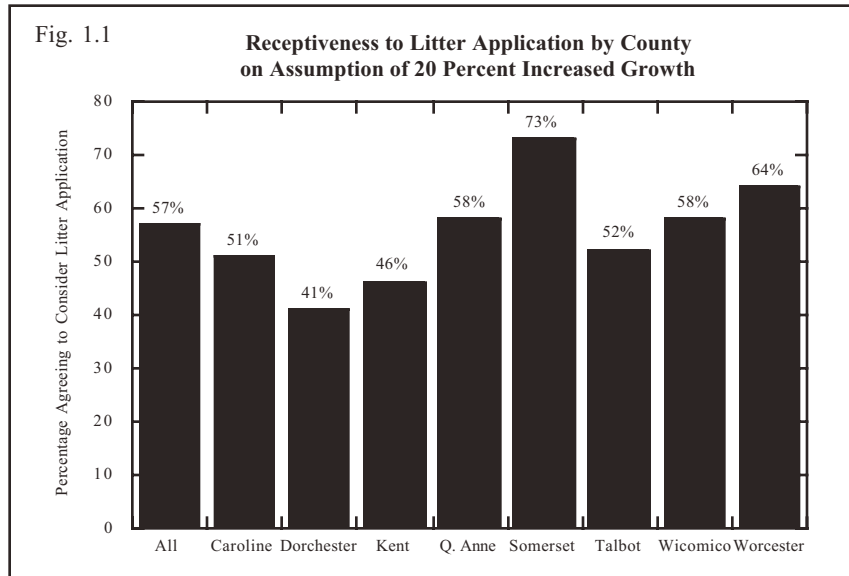
1.A The Poll

From the state Department of Assessment and Taxation, the Maryland Cooperative Extension obtained tax records for the 4,000-odd landowners with forest lands on the Eastern Shore of Maryland, composed of Caroline, Cecil, Dorchester, Kent, Queen Anne's, Somerset, Talbot, Wicomico and Worcester counties. Cecil County was found to have relatively few forestry tracts or poultry houses, and so as a result was excluded from the survey. We solicited proposals from polling companies, and selected Mason-Dixon Polling and Research, Inc., based in Columbia, Maryland as our vendor. Mason-Dixon agreed to survey about one-tenth of the Shore landowners,

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giving a degree of confidence of +/- 5.0 percent, standard for polls of this nature. Though the tax records did not come with telephone numbers, Mason-Dixon was able to use a "telematch service" to locate more than enough numbers.

A 24-question survey tool was devised, reviewed and approved by a seven-person committee made up of: Sharon Carrick (secretary/treasurer of the Association of Forest Industries, Inc., or AFI), Brooks Clayville (president of Eastern Precision Services, the soil sampling company), Lori Lynch (an assistant professor of agriculture and resource economics at the University of Maryland), William Miles (executive director of the AFI), Douglas Munro



(owner of InterGroup Services, a consulting firm contracted to AFI), Jack Perdue (a public lands steward with the state Department of Natural Resources) and Robert Tjaden (a regional extension specialist at the Maryland Cooperative Extension). Mr. Perdue did not find either the survey content or the project as a whole to conflict in any way with his department's Integrated Watershed Analysis and Management System (IWAMS). The survey containing the questions was administered by Mason-Dixon telephone operatives between June 8-17, 2000 to 402 Eastern Shore forest landowners. The questions themselves may be found in the appendix section of the Mason-Dixon report, which is being released simultaneously with this analytical report.

Though results varied by county, the most singular fact emerging from the poll is that forest landowners are very much prepared to consider applying chicken litter to their pine stands. Overall, 57 percent of respondents said they would be happy to consider chicken-litter application with no incentive other than the assumption of increased tree growth. In other words, even without government subsidies, a solid majority of Shore landowners are prepared to review chicken litter's potential. As Figure 1.1 shows, a majority of landowners are receptive to chicken litter in all but two counties (Dorchester and Kent). Appendix 1.1 breaks these data down in tabular form and also gives county by county approval rates when various hypothetical government incentives are

included in the equation. (For reasons explained in section 2, readers should be careful comparing approval rates under the "no incentive" question with the approval rates generated under the various incentive scenarios. Additionally, Figure 1.1 and the table at Appendix 1.1 present raw data, without the econometric considerations described in section 2 of this report. This is to say, figure 1.1 and Appendix 1.1 do not isolate those county-specific characteristics that might influence each respondent's willingness or lack of will-

ingness to consider using poultry litter as a forest fertilizer. For example, if the graph indicates that Somerset County residents are most agreeable to the use of poultry litter, this may be because they come from Somerset County, or it may be because the respondents from Somerset County happen to exhibit other characteristics that predispose them to look favorably upon poultry-litter use, such as age, income, acreage, etc. The econometric technique used in section 2 segregates all these characteristics, allowing us to determine the degree to which county of residence *alone*, or age *alone*, or income *alone* influence landowner attitudes. Where the data in Figure 1.1 and Appendix 1.1 table differ from those in section 2, the section 2 data should be taken in preference to these.)

Details aside, the fact is, when incentives are considered, two-thirds of forest landowners are prepared to give serious consideration to chicken-litter usage. With a hypothetical property-tax reduction, 67 percent said they would consider litter application. When an income-tax break was proposed, 63 percent said they would. If the state offered some sort of cost-sharing subsidy, in effect reducing the cost of litter application to little or nothing, 64 percent would favor it or consider it. One other proposed incentive, a flat-rate, one-time payment by the government to the landowners of \$20 per acre generated far less enthusiasm, for reasons discussed in section 2.

1.B The Soil

Having ascertained that landowners are willing to give chicken litter a try, it remained to establish if the forested soils of the Eastern Shore could safely absorb chicken-litter nutrients without causing runoff into the bay. Eastern Precision Services, LLC was contracted to take and analyze 240 soil samples. To his own 240 samples, Eastern Precision President Brooks Clayville added another 50 samples he had obtained from Chesapeake Forest Products, Inc., for a total of 290 samples taken from all eight counties comprising the survey area (i.e., Maryland's Shore counties minus Cecil County).

"Our hypothesis proved to be entirely correct.... Suffice it here to say that — for all the elements tested, phosphorus, potassium, magnesium, calcium and acidity — the vast majority of the 290 soil samples rated low or very low. Plainly put, there is plenty of absorbing capacity within Eastern Shore forested soils."

Agricultural soils on the Shore exhibit high levels of nutrients because of years of repeated fertilizer application. The fertilizer nutrients saturate the soil, making it unable to absorb any more — so the nutrients instead run ultimately into the bay. Our hypothesis was that forested soils, which are rarely if ever fertilized, would exhibit low levels of nutrients — meaning they would be capable of absorbing a considerable quantity of nutrients safely.

Our hypothesis proved to be entirely correct. Soil samples were air-dried and shipped to the laboratory for analysis. Each sample was analyzed for reserve and available phosphorus, potassium, magnesium and calcium. Nutrient distributions for each sample were then plotted using Maryland's soil fertility index values. The results for the individual samples are shown at Appendix 3.1. Suffice it here to say that — for all the elements tested, phosphorus, potassium, magnesium, calcium and acidity — the vast majority of the 290 soil samples rated low or very low. Plainly put, there is little likelihood of running afoul of state nutrient-management requirements in applying litter on forest land.

I.C. The Meetings

In addition to polling forest landowners and sampling the soil, we helped facilitate a number of public forums to discuss the issue of applying manure to forest land as fertilizer. This was accomplished over the course of the project period, reaching some 275 decision makers, including some from Brazil.

The following programs were held to discuss the topic over the project period:

- Delaware Forest Association annual meeting, April 6, 2000, Harrington, Delaware. Approximately 80 landowners, forestry-industry representatives and policy makers in attendance.
- Society of American Foresters summer meeting, May 25, 2000, Clinton, Maryland. Approximately 70 foresters in attendance.
- Lower Eastern Shore Tributary Team meeting, May 30, 2000, Salisbury, Maryland. Approximately 25 people in attendance.
- Maryland Tree Farm annual meeting, June 15, 2000, Easton, Maryland. Approximately 50 forest landowners, policy makers and foresters were in attendance.
- Rural Development Opportunities — Application of Poultry Manure to Pines as a Fertilizer, July 27, 2000, Salisbury, Maryland. Approximately 40 nutrient-management specialists, poultry-industry representatives, landowners, foresters, forest-industry representatives, land-use consultants and media members were in attendance.
- University of Maryland faculty and visiting scholars from Brazil meeting, August 31, 2000, Wye Research and Education Center, Wye Mills, Maryland. Approximately 10 agronomists and land managers were in attendance.

We intend to continue presenting these materials to future gatherings of persons involved in agriculture and silviculture in the mid-Atlantic.

We have also compiled an impressive compendium of studies related to this issue. This compendium forms the bibliography section of the report. Many of the publications cited are on-line and, where this is the case, an Internet uniform resource location (URL) is provided for the reader's convenience.

Table 1.1 summarizes this report's main findings.

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Table 1.1

Key Findings

1. For the first time, the State of Maryland now has a reliable database of Eastern Shore forest landowners.
2. Eastern Shore forest landowners are remarkably open to the idea of using poultry litter as fertilizer:
 - 57% for will consider using poultry manure with no incentive offered other than the supposition of increased growth.
 - 67% will consider using poultry manure if given a property-tax incentive.
 - 64% will consider using poultry manure if given a cost-share incentive.
 - 63% will consider using poultry manure if given an income-tax incentive.
3. Our analysis of 290 forest soil samples demonstrates that nutrient values within Eastern Shore forested lands are remarkably low. Measured on the Maryland soil fertility index, and based on close analysis of all 290 samples taken from all over the Eastern Shore, we find that:
 - 84.9% of forested soils have phosphorous levels in the “very low” or “low” categories.
 - 94.1% of forested soils have potassium levels in the “very low” or “low” categories.
 - 72.8% of forested soils have magnesium levels in the “very low” or “low” categories.
 - 99.3% of forested soils have calcium levels in the “very low” or “low” categories.
 - 68.6% of forested soils have acidity levels below pH 4.5.



2. Landowners' Attitudes toward Poultry Litter

by Lori Lynch and Robert Tjaden

Dr. Lynch is an assistant professor in the Department of Agricultural and Resource Economics at the University of Maryland. Mr. Tjaden is a regional extension specialist at the Maryland Cooperative Extension.

2.A Introduction

Approximately 625 million chickens are raised on the Delmarva Peninsula each year, producing more than 750,000 tons of manure (Goodman 1999). If the feeding recommendations of the National Research Council are followed, these flocks will excrete 53 million pounds of manure nitrogen (N) and 22 million pounds of manure phosphorus (P) each year — two nutrients that can have a potentially adverse impact on water quality. Poultry farming therefore represents one of the significant sources of nutrients with a potentially adverse impact on water resources (Coll. of Ag. and Nat. Resources 1997).

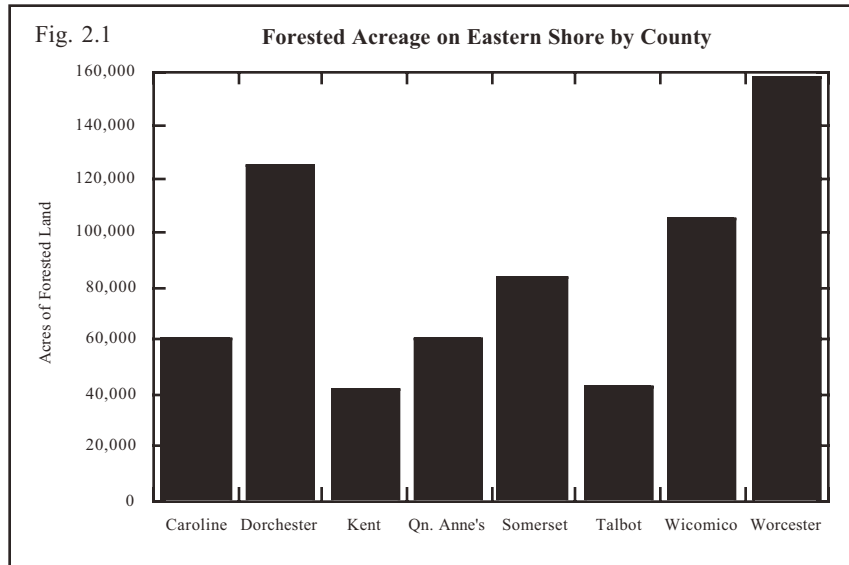
The poultry house owners dispose of this poultry litter by spreading it onto crop land, where it is used as fertilizer. Recent research has shown that soils with very high phosphorous levels may need more than sediment control to prevent phosphorus runoff from these fields. According to researcher Frank 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. Coale finds that the average P fertility of soil samples voluntarily sent to the University of Maryland's soil testing lab for soil fertility analysis and fertilizer application recommendations has increased steadily over the past 40 years.

In response to concerns about the levels of nutrients in Maryland waterways, the General Assembly passed the Maryland Water Quality Improvement Act of 1998, which may curtail application of poultry litter as fertilizer in certain areas (Parker 2000). Other uses or other destinations must therefore be found. If poultry litter is to be used as fertilizer, yet is restricted from use on crop land in the lower Eastern Shore because of current high soil phosphorus

levels, it must be transported to more distant destinations. Parker finds that the cost of poultry manure application from poultry house to the 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 would be \$15.75 million — if sufficient crop land were even available on the upper Eastern Shore. The higher overall cost of poultry production that would result from increased transportation costs could jeopardize the profitability of the industry. Such a decline would impact the entire state. A University of Maryland study of the economic impact of the Delmarva poultry industry estimated that a four percent decline in Maryland's poultry production would result in 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 (Musser and Mallinson 1996).

If the Maryland Water Quality Improvement Act restricts crop land application on phosphorous-enriched soils, poultry growers must find new crop land or alternative methods of utilizing the litter. High transportation costs are a concern when evaluating alternative uses. But if forest landowners closer to the chicken houses were willing to employ the litter, not only would the cost of transporting it be reduced, but forest landowners would be able to increase tree growth. This could be a win/win situation.

It turns out that forest systems can filter and transform nutrients such as nitrogen and phosphorous (Palone and Todd 1997), fortunately. There are almost 678,500 acres of forest land in the eight counties on Maryland's Eastern Shore surveyed for this study, as illustrated in Figure 2.1. Many of these acres have low levels of phosphorus.



As described further in section 3, Eastern Precision Services found the average soil P level to be 14.9 parts per million (ppm) in the sampled forest soils after an analysis of a total of 290 soil samples. The average agricultural field on the Eastern Shore would ordinarily measure between 80 and 215 ppm. The mid and lower counties on the Delmarva Peninsula (Caroline, Dorchester, Somerset, Talbot, Wicomico and Worcester) are the major producers of wood fiber for the area's pulp, paper and lumber industries, and lie in close proximity to areas of concentrated poultry production. If one assumes that the establishment and thinning of pine plantations in any one year is approximately 13,000 acres (3,000 to 5,000 newly established plantations at one ton an acre and 8,000 to 10,000 mid-rotation thinnings at two tons an acre), then 20,000 to 23,000 tons of poultry litter could be applied on forest land annually (Tjaden and Garret 1999).

The Association of Forest Industries (AFI) and Maryland Cooperative Extension (MCE) have therefore sought to determine forest landowners' willingness to use poultry litter on their land as fertilizer under a variety of financial incentive mechanisms. As demonstrated in the text that follows, a majority of Eastern Shore forest landowners are willing to consider poultry litter as a fertilizer for their land. As further demonstrated in section 3, the forest soil itself is quite capable of absorbing common chicken manure nutrients.

2.B The Respondents

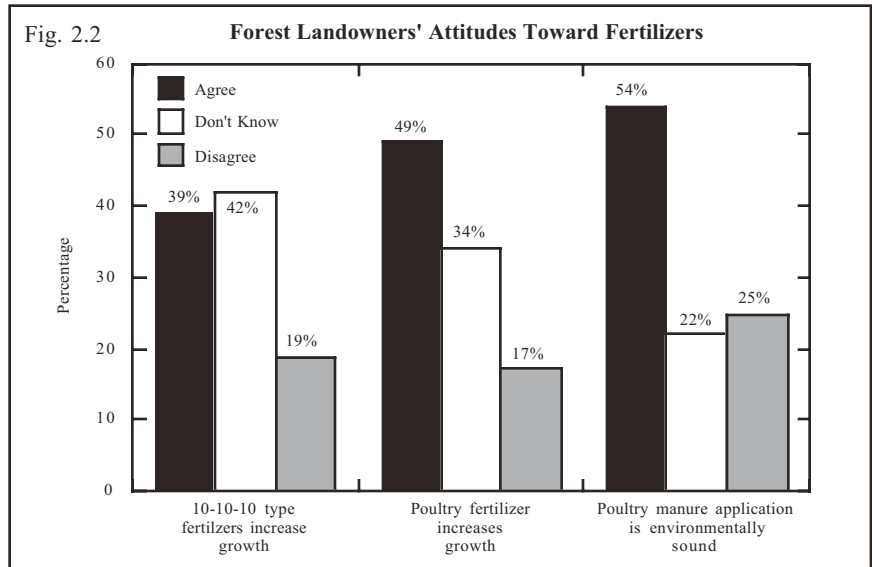
In the spring of 2000, AFI and MCE commissioned a Mason/Dixon telephone survey of 402 forest landowners in eight counties: Caroline (12 percent of the total surveyed), Dorchester (15 percent), Kent (6 percent), Queen Anne's (9 percent), Somerset (15 percent), Talbot (7 percent), Wicomico (19 percent), and Worcester (18 percent). The initial calling list was derived from publicly available tax records. Only those who owned or managed 40 or more acres of

land, with at least five contiguous acres of forest land, were contacted for participation.

Most respondents proved to be small landholders: 59 percent owned fewer than 50 acres of forest land, while only 20 percent owned more than 100 acres. (See Appendix 2.1 for a detailed breakdown of the respondents' characteristics.) Of the 90 percent of the respondents with pine trees, 37 percent stated that their pine stands made up 50 percent or less of the forest land they owned; just over one-quarter of the respondents reported that 75 to 100 percent of their forest land was in pine.

Ninety-three percent of survey respondents reported that they privately owned their own land. (Throughout this document, reported percentages are based on the number of people responding to each question.) Appendix 2.1 presents the means and standard deviations for the survey sample.

Twelve percent said they had owned their land for less than five years; 12 percent, from 6 to 10 years; 25 percent, from 11 to 20 years; 15 percent, from 21 to 30 years; and 37 percent, for more than 30 years. Forty-two percent of the sample reported currently having a forest-management plan. Almost 60 percent said they had sold timber from their land at some point in the past. Thirty-eight percent had been assisted by foresters in these sales. Eleven percent claimed to have sold timber within the last 2 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 the 347 landowners who said they had agricultural land next to their timber land, 32 percent said they farmed it themselves (“owner/operators”), while 43 percent said they leased the farmland to others. Twenty-two percent of the respondents reportedly earn less than 10 percent 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 25 and 50 percent, and 7 percent earn between 50 and 100 percent from such activities.

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.

2.C Attitudes about Use of Litter

Many respondents, 49 percent, agreed that poultry litter was an acceptable fertilizer. However, more forest landowners need to be educated about poultry litter as fertilizer if using poultry manure on forest land is to become an alternative usage strategy. Almost half of all respondents agreed that poultry litter was an effective fertilizer for increasing growth and

profit from timber sales. By comparison, only 39 percent considered commercial fertilizers to be effective. Nonetheless, as shown in Figure 2.2, it remains the case that 34 percent of respondents did not know whether chicken litter might fertilize effectively, and 17 percent disagreed.

More than half of the respondents (54 percent) agreed that the application of poultry litter to forest land was a sound environmental practice when done as part of a nutrient-management plan. Again,

there remains some need to educate landowners further, as 25 percent said they disagreed and another 22 percent responded that they did not know or provided no answer. Having said this, respondents had a higher level of agreement with poultry litter as an environmental practice than they exhibited in their views about commercial fertilizers. 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 (compared to a 17 percent negative response rate for chicken litter).

These views are not entirely unexpected, given the longstanding 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, Allen, Dougherty, Kress and King 1998; Allen 1994; Allen and Lein 1998; Allen, Weir and Goldfarb 1998; Bailey and Borders 1998; Moorehead 1997; and Moorehead 2000).

Awareness about forest fertilization was positively correlated between the different attitudinal statements. For example, people who agreed that commercial fertilizers increase pine tree growth were more likely to agree that

poultry litter increases pine tree growth. Interestingly, although one might think that currently having a forest-management plan would have some impact on attitudes and awareness, there was no relationship found between respondents' attitudes and whether or not they had a plan. One possible explanation comes from earlier research by Thomas Birch (1994), who found that only three percent of Maryland forest landowners cited timber production as one of their top reasons for owning forest land. Therefore, it is possible that foresters do not emphasize growth potential when designing these management plans. In addition, foresters may be discouraging, or at least not actively encouraging, fertilizer use, including poultry litter, among their clientele. This could present an educational opportunity to stimulate more demand for poultry litter.

Respondents did differ, however, in their attitudes by their likelihood of selling timber in the future. Those who were likely to sell timber in the future agreed that using litter was an environmentally sound practice and that it was a fertilizer that would increase growth and profits; those who were unlikely to sell timber in the future disagreed.

Educational level had no influence on respondents' views. Nor did the number of years of farm ownership. But respondents who earned a lower percentage of their income from farming and forest-management activities were more likely to say they "did not know" whether they agreed with the survey statements about poultry litter, while those who earned a higher percentage of their income from these activities were more likely to agree. Past sales of timber did not seem to impact a respondent's attitudes about poultry litter as a fertilizer or as an environmentally sound practice.

In terms of attitudinal variation within the region, Worcester, Wicomico and Somerset county respondents were the most likely to agree that using poultry litter as fertilizer increased growth and profits. These counties have the highest concentration of poultry houses. Given this fact, these respondents may already have used poultry manure on crop land and thus have realized that it can be used to increase profitability. Respondents in counties with lower concentrations of poultry houses, such as Kent, Queen Anne's and Talbot

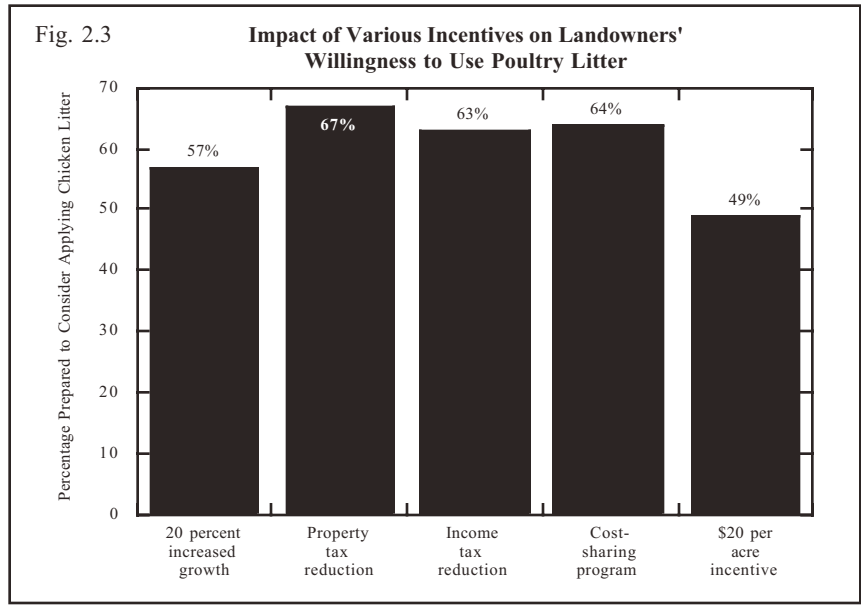
counties, were the most likely to say they did not know if poultry litter would increase growth. Survey respondents living in Caroline and Dorchester counties were most likely to disagree that it would. These landowners may need additional educational campaigns or some farmer-to-farmer programs to become knowledgeable about, and interested in, using poultry litter. The county of residence had little impact on a respondent's agreement or disagreement with the statement that using poultry litter is an environmentally sound practice.

2.D Willingness to Use Poultry Litter

A majority of survey respondents indicated a willingness to consider using poultry litter, even with no government incentive offered. This is the most important finding of this report. As shown in Figure 2.3, 57 percent of the survey respondents said that they would consider using poultry manure if this increased pine growth by 20 percent, even with no mention of a government incentive. 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 about their willingness to use poultry litter as a fertilizer. Over a quarter of respondents strongly agreed, and another 31 percent somewhat agreed. Thirteen percent said they did not know whether they would consider it.

2.E Comparing Incentives

Respondents' views were explored further by asking about their willingness to consider chicken-litter use if offered a variety of publicly funded incentives, these being: (a) a reduction in property taxes, (b) a reduction in state income taxes, (c) a cost-sharing arrangement whereby the state subsidized most or all of the cost of litter application and (d) a one-time payment of \$20 an acre to encourage use.



These data should be interpreted with caution. The questions pertaining to government incentives assumed the landowner would realize the same 20 percent increase *plus* the incentive in question. Logically, we expected to see more enthusiasm on the part of growers for each of the incentives than for just the hope of increased yield alone. For all the incentives but one, this proved to be the case. However, one incentive — the \$20 one-time payment — proved to be *less* popular than no government incentive (49 percent support compared to 57 percent). Even if respondents consider a \$20-an-acre payment a small amount, few people would consider no payment to be preferable to some payment. As an explanation for this apparent anomaly, we believe that a number of respondents may have supposed that the government incentives would be somehow offered *instead* of the increased growth, rather than *as well as* the growth. This misunderstanding was presumably evenly distributed across all the government-incentive questions, so we believe these may be compared to one another. However, support for the various government incentives should not be compared against the “no incentive” category. The “no incentive” category is presented in Figure 2.3 next to the other incentives for the reader’s convenience. But no comparisons or inferences should be drawn from this.

The property-tax reduction was the most popular incentive. Two-thirds of respondents

said they either would use or would consider using chicken litter as a forest fertilizer if given a break on property taxes. (See Figure 2.3.) Sixty-three percent said they would consider a poultry litter application if offered a reduction in state income taxes. A similar sixty-four percent agreed that, if Maryland provided a cost-sharing program which defrayed the cost of application of poultry litter, they would consider applying it. However, fewer than half of the respondents (49 percent) said they would agree to apply poultry litter if the

incentive were a one-time payment of \$20 per acre. For each of the proposed incentive schemes, about 10 percent of respondents did not know whether they would use poultry litter or not. Fewer than 30 percent would be unwilling to use the manure under all incentive mechanisms, except the \$20-per-acre one. Almost 40 percent of the respondents would not consider poultry litter use under a one-time \$20 per acre incentive payment. Appendix 1.1, referred to on page 4, shows how the different counties responded to each of the incentives.

The benefit to landowners provided by the different incentive mechanisms varies. Policy makers may want to select the incentive mechanism that gives the highest degree of landowner willingness for the lowest cost to the state. However, this may not be easy. It is difficult to determine actual implementation costs and the benefits to the landowners. For example, the benefits resultant from state income-tax reductions would depend on a landowner’s income. The cost to the implementing agency would also depend on the reduction offered.

A cost-share program could leave landowners with little or no cost for the litter application. And if the landowner ordinarily used commercial fertilizer in a pine stand establishment, using the costless poultry litter would save the landowner the cost of the commercial fertilizer. Doug Parker has found

the savings in commercial fertilizer costs from using poultry litter on corn instead of commercial fertilizer to be \$23.07 per ton of manure (Parker 1998). If the cost savings for a forest landowner were similar, and if we assume an application rate of two tons per acre, the savings would be \$46.14 per acre. The cost of application of poultry litter to a pine stand establishment is not known at this point; therefore, the cost to an implementing agency of this type of cost-share program cannot be calculated.

The enthusiasm for the hypothetical property-tax incentive was interesting, given the relatively low level of property taxes on agricultural and forested parcels in the state. Typical county property-tax rates are \$2.29 per \$100 of assessed value. The state rate is \$0.21 per \$100 (Department of Assessment and Taxation 1995). The combined county and state tax rates are thus \$2.50 per \$100 of assessed value. Given Maryland's preferential agricultural taxation laws, the average agricultural use value for agricultural land is \$300 per acre. The average agricultural use assessment is 50 percent of this \$300, or \$150 per acre. Therefore the property tax owed is \$3.75 per acre per year (\$2.50 divided by \$100, with the answer multiplied by \$150). If the property-tax incentive were provided for the entire life of the stand's rotation, this could be \$3.75 per acre per year for 20 to 30 years. The present value of this property-tax reduction incentive is \$46.73 per acre, if one assumes a five percent interest rate and a 20-year stand. The cost to the implementing agency of this incentive mechanism, if it paid the tax for the landowner to the county, would depend on how many years of tax forgiveness were granted.

While, overall, the majority of respondents agreed to consider poultry litter use as a fertilizer on their forest land, the one-time \$20 per acre incentive inspired the least such willingness. Respondents obviously valued the other incentive mechanisms more than they valued the once-only \$20 per acre payment, with the differences ranging from 14 percent more respondents valuing a state income-tax reduction to 18 percent more respondents valuing the property-tax reduction. One reason may be that the cash option ends up being a lower dollar value than it might initially seem.

In most cases, cash incentive payments are added to the taxpayer's income and then taxed. If a landowner happened to be in the 28 percent tax bracket, the taxes owed on a \$20 incentive payment would be \$5.60 (\$20.00 multiplied by 28 percent). Therefore, the real value of the \$20 minus the taxes owed of \$5.60 would be \$14.40. This would be \$32.33 less than the number calculated per acre for the property-tax incentive (\$46.73 minus \$14.40).

2.F Regression Analysis

In addition to the information offered above, this analysis uses survey responses to determine landowner willingness to adopt poultry litter by employing an ordered response probit model. We can investigate similarities as well as differences among the respondents as to which land, farm or personal characteristics impact adoption preferences. By using a limited dependent variable model, the marginal contributions of each characteristic affecting respondents' willingness can be isolated. The details of the econometric technique used are provided at Appendix 2.2.

2.F.1. Increased Growth

The estimated coefficients resulting from explaining willingness to use poultry litter after being informed that it could increase growth by 20 percent as a function of demographic, farm and land characteristics are found in Appendix 2.3. By isolating individual farm, land and demographic characteristics' impact on agreement, we found that farmers with more than 200 acres were more likely to consider poultry-litter use than were farmers with fewer than 50 acres. Respondents who lived in Somerset and Wicomico counties had a higher degree of agreement than respondents in other counties. Farmers who owned and farmed their land themselves were also more willing to consider using poultry manure than those who leased or did not farm. Younger farmers were more likely to consider using it than farmers over 60 years of age. Although having sold timber at any time in the past did not significantly impact willingness, if the respondent had conducted a sale more than five years previously, he or she was less likely to agree than someone who had conducted a sale within the last two years.

Interestingly enough, many seemingly important characteristics and actions of the respondents did not impact their willingness to apply poultry litter. One might consider that employing a management plan would suggest that the landowner would consider other management tools. Yet, currently having a management plan did not impact respondents' willingness to use poultry litter. In addition, having had the help of a forester with a timber sale in the past might suggest ongoing contact with a forester. But having had the help of a forester in the past did not seem to affect a respondent's willingness in a significant way. As mentioned above, some foresters may not perceive fertilizer use, and thus poultry-litter use, as being a sound management practice; they may thus be discouraging, or at least not encouraging, landowners in this regard.

If respondents are more likely to use fertilizer when reestablishing a stand of trees, one would also expect that the number of years the respondent had owned the farm, and possibly his/her thoughts toward future sales, would impact his or her response, but neither had a significant impact.

Education and gender also did not appear to impact a respondent's willingness to consider using poultry litter.

2.F.2. The Property Tax Incentive

More respondents would be willing to consider poultry litter as a fertilizer for their forest land if offered a reduction in property taxes than if offered any of the other three incentives. The estimated coefficients pertaining to the property-tax reduction incentive as a function of demographic, farm and land characteristics are found at Appendix 2.4. Most of the variables that explained willingness to use poultry manure when it increased growth by 20 percent also are significant in explaining willingness under the property-tax incentive. People less than 60 years old and respondents with farms larger than 200 acres compared to those with farms of less than 50 acres are more likely to agree. Somerset County respondents remain more willing than respondents in other counties. Also, the timing of a past timber sale was statistically significant with respect to this incentive: People who had sold timber more than two years previously proved less likely to

be willing to use poultry manure than those who had sold timber within the last two years — or those who had never sold timber. Respondents who actually farmed the land were not more willing under this incentive scheme than those who leased or did not farm the land.

2.F.3. The Income Tax Incentive

The estimated coefficients for willingness to use poultry litter by an income-tax incentive as a function of demographic, farm and land characteristics are found within Appendix 2.5. Respondents who own farms of more than 200 acres were more willing to use poultry manure when income-tax incentives were suggested than respondents with farms less than 50 acres. In addition, if the landowner was less than 60 years old, he or she was more likely to consider using poultry litter than those 60 years old or older. Again, the number of years since the last timber harvest affected willingness. Those who had sold timber between 3 and 10 years previously were less likely to agree to consider poultry-litter use than those who had sold in the last two years. When offered this incentive, respondents from Somerset, Wicomico and Worcester counties were no more and no less willing to use poultry litter than respondents in the other counties. In addition, whether the land was farmed by the owner, leased out or not farmed did not appear to impact a respondent's willingness to use poultry litter.

2.F.4. The Cost-Share Incentive

Appendix 2.6 gives the estimated coefficients resulting from explaining willingness to use poultry litter with a cost-share program incentive as a function of demographic, farm and land characteristics. Farmers with more than 100 acres were more likely to look favorably on the cost-share idea than were farmers with 50 acres or less. Younger farmers (less than 40 years old) appeared more likely to find a cost-share program an adequate incentive to apply poultry litter than farmers who were more than 60 years old.

2.F.5. The \$20 per Acre Incentive

Please see Appendix 2.7 for our estimated coefficients resulting from 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. Farmers who owned more than 200 acres were more likely to respond positively to this incentive than farmers who owned 50 or fewer acres. Somerset County respondents were statistically more likely than others to agree to use poultry litter under this incentive scheme.

In this case, respondents who had sold timber in the past were also more likely to agree under this incentive structure than those who had never sold timber. If the respondent had sold timber more than five years previously, he or she was less likely to agree to consider using poultry manure than someone who had sold in the last two years. If a forester had assisted a respondent with a timber sale sometime in the past, then the respondent was more willing to consider using the litter. Surprisingly, farmers who currently had a timber-management plan were less likely to agree to use poultry litter compared to those without a management plan.

Farmers who were less than 60 years old were more likely to agree to use poultry manure under this incentive. Farmers who had owned their farms for 6 to 10 years were less willing to use poultry litter than farmers who had owned the farm less than six years. However, having owned the farm for more than 10 years appeared to have no more effect on willingness than having owned the farm for less than six years. As mentioned above, there may be some need to educate the forestry community.

2.G Conclusions

The majority of the forest landowners surveyed are willing to consider poultry litter applications. A majority of survey respondents indicated their agreement to consider using poultry manure as fertilizer on their pine trees, even with no incentive other than increased tree growth. Educational programs are needed to inform those who disagree with litter application, or who do not know whether they would consider using poultry litter, that the litter can have positive benefits on their forest land and that their use of the litter could improve environmental conditions on the Eastern Shore. The majority of respondents would agree to use poultry litter for its growth impacts. However, if policy makers want to motivate those respondents who responded “do

not know” or “disagree,” some type of incentive program will be necessary. Our survey results provide some preliminary information for designing such a program.

Property-tax incentives induced the highest level of willingness. Of the four incentive schemes included in the survey, the offer of a property-tax reduction resulted in the most willingness to consider using poultry manure on forest land, with 67 percent of respondents agreeing. However, income-tax reductions and cost-share incentives were not a great deal lower, with 63 percent and 64 percent of the respondents, respectively, indicating willingness under those two schemes. Fewer than half of the respondents (49 percent) agreed when offered the one-time \$20 per acre incentive payment.

Farmers with larger acreage were more likely to agree than farmers with smaller farms. Under all the incentive options, farmers with more than 100 or 200 acres were more likely than those with fewer than 50 acres to agree to use poultry litter. This suggests that targeting outreach efforts to farmers with more acreage might be the best strategy. In addition to farmers with more acreage, landowners in Somerset, Worcester and Wicomico counties might be approached first, since respondents in those counties indicated a higher level of willingness to use poultry litter than respondents in other counties. Overall, younger farmers also expressed a higher level of willingness to consider poultry manure applications than did older farmers.

Education of foresters may be needed. The fact that currently having a timber-management plan did not appear to impact willingness — except in the case of the one-time \$20 per acre incentive payment, where it *decreased* willingness — suggests the need to further educate the community that assists forest landowners in designing management plans about the benefits of fertilizer use and especially poultry manure on forest land.



3. Analysis of Eastern Shore Forest Soils

by Brooks Clayville

Mr. Clayville is the president of Eastern Precision Services, LLC.

3.A Introduction

The purpose of this chapter is to describe the degree to which all parties would benefit by the application of chicken manure to forest lands. If it were found (a) that forested lands were more capable of absorbing manure nutrients than agricultural land and (b) that such manure would improve pine growth, then both poultry and timber growers would benefit considerably. The forestry grower would be provided with a low-cost means of increasing yield, while the poultry farmer would, at least in part, be relieved of the headache of trying to dispose of manure in an environmentally friendly manner. The purpose of chapter 2 was to describe the receptiveness of timber growers to the idea. The purpose of this section is to describe the environmental feasibility of applying chicken litter to forested lands.

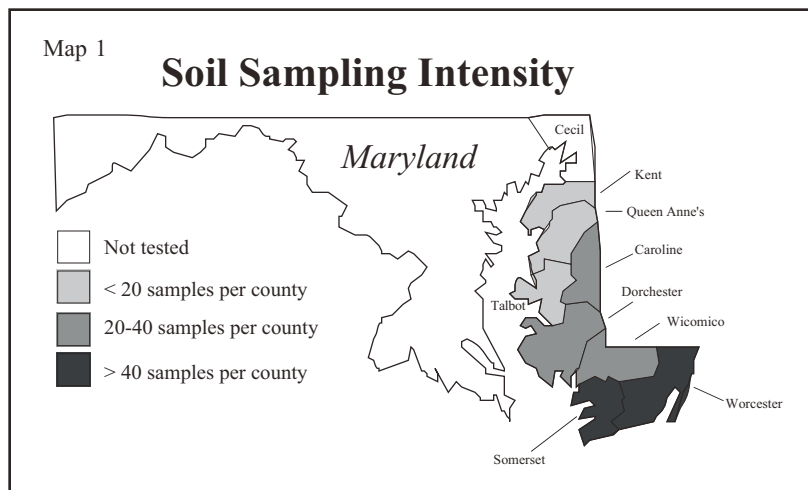
Concerns over poultry manure on the Delmarva are increasing, as documented elsewhere in the report. Historically, most poultry manure generated on the peninsula has been applied as fertilizer upon farmlands. Environmental fears, mostly relating to nutrient runoff into Chesapeake Bay, have induced the State of Maryland to promulgate regulations to limit the quantities of raw chicken manure applied to fields. Eventually, state-regulated nutrient management planning may well entirely eliminate manure application upon agricultural lands. In the interim, at minimum, poultry farmers on the nutrient-saturated lower Shore may have to spend considerable sums transporting their excess manure to other places. For the time being, this will include the nearby upper Shore, where there prevail lower concentrations of manure nutrients within agricultural soils. This can only be regarded as a stopgap measure, however. In time, upper Shore agricultural lands will become as nutrient-sated as those of the lower Shore.

As the result, alternative manure disposal methods must be sought and evaluated. Absent such alternatives, if state regulations are to be adhered to, there will have to be a dramatic reduction in the amount of poultry farming on the Shore — with potentially severe economic ripple effects upon the whole region, as described in chapter 2.

Forestry and forest products are the Eastern Shore's second-largest industry. Recent studies, such as one by North Carolina State University Professor H. Lee Allen, show that timber growth of managed forest stands can be increased if these stands are fertilized (Allen 1994). Currently, such stands are not fertilized, for the most part. The soil in which such stands are planted is, therefore, the chemical equivalent of a dry sponge, at least compared to the heavily fertilized agricultural soils nearby. Theoretically at least, forested soils should be able to absorb more manure nutrients, thus easing concerns about runoff into the bay.

Consider a two-acre area of soil. One acre has been continuously farmed for crops for 40 years. The other acre has been in permanent forest. A soil sample taken from the forested portion will almost certainly show extremely low levels of common agronomic nutrients — phosphorus, potassium, calcium and magnesium. A soil sample taken from the farmed portion of the soil will likely show high levels of the same nutrients, caused by years of fertilizer application. Even though the soils are the same in derivation, man's activities have increased the fertility levels of the farmed portion of soil.

We determined to test hundreds of soil samples to discover the extent to which this hypothesis was true. In sum, thus, this study was conducted to assess the levels of nutrients within forested soils on the Eastern Shore of Maryland, and to determine their general capacity to receive nutrients in accordance with Maryland's nutrient-management guidelines.



3.B Sample Locations

Nine counties comprise Maryland's portion of the Delmarva Peninsula. Of these counties, eight have a significant number of managed forest stands, the exception being Cecil County on the northernmost portion of the Shore. In order to render our soil sampling survey comprehensive, soil samples were collected from each of the southern eight Shore counties (Caroline, Dorchester, Kent, Queen Anne's, Somerset, Talbot, Wicomico and Worcester). We collected and analyzed 240 soil samples in total. These samples were taken from each county based loosely on the amount of forested land in each county and the amount of poultry produced in each county. Thus, more soil samples were collected from the lower three Shore counties (Worcester, Wicomico and Somerset) than the remaining counties in the study. Map 1 depicts the distribution of soil samples in the study.

In addition to the soil samples collected specifically for this study, another 50 soil samples were provided by the former Chesapeake Forest Products, Inc. These samples had been taken as part of their forest management and fertilization program. The exact procedures for the collection of these 50 samples are unknown, and may have differed somewhat from our own, though probably not significantly. The University of Maryland soil analysis laboratory analyzed these samples. The results were not noticeably different from our own, and so we have included these results in all the statistical citations within this document.

3.C Soil Variability

Throughout the Delmarva, the soils share similar origins and parent materials. Despite this lack of diversity, the soils within the study area show considerable variability in their ability to sustain forest production. The variability among soils is caused mainly by differing textures (loamy sands to clay loams) and drainage classes (excessively drained to very poorly drained), rather than by differing chemical composition. The Eastern Shore

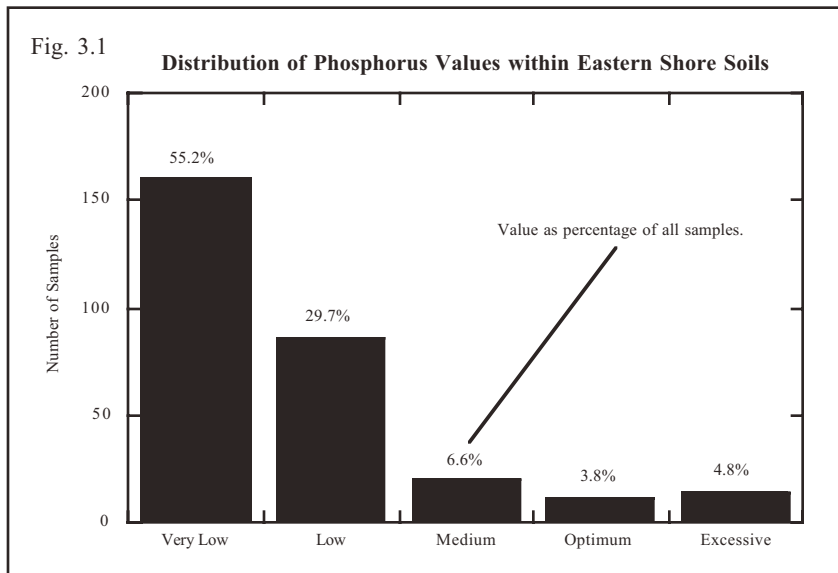
lies within the Atlantic Coastal Plain physiographic province, and the soils of the region are formed in sediments that were deposited in marine and shallow-water environments.

The majority of managed forest stands on the Shore occur on sandy, excessively drained soils or clay loam, poorly drained soils. This is because these two soil types are difficult to farm and thus less profitable to use as crop land. We collected soil samples from many different soil types covering the entire spectrum of variability occurring on the Shore. All soil samples were collected in forests (as opposed to agricultural areas), although not all these forests were actively managed for timber production.

3.D Soil Sampling

Soil samples were collected using a step probe. Once a sample location had been chosen, all duff and other debris were removed from the surface, leaving bare soil. The sampling probe was inserted in the soil to a depth of approximately eight inches and removed. This depth was determined to be the maximum depth that surface application of nutrients could be effectively managed. Each soil sample represented an area of 15 to 25 acres, except in some cases where a smaller sample area was chosen to fit a smaller tract of forest or a particular soil type.

Samples were air-dried and shipped to the laboratory for analysis. Each soil sample was analyzed for reserve and available phosphorus, potassium, magnesium and calcium. Soil organic



The approach here is to show the distribution of all the samples for each nutrient analysis. The distributions are plotted using Maryland’s soil fertility index values, as these values are to be used for all nutrient-management planning in the state. Maryland has developed these indices for each agricultural fertility component. These indices allow for comparisons and recommendations to be made for soil samples taken from any area of the state and analyzed by most private and public laboratories.

matter, pH level and cation exchange capacity (CEC) were also discovered. All analyses are given in Appendix 3.1. A&L Eastern Agricultural Labs of Richmond, Virginia performed the analysis of our 240 samples. Analysis values were then converted to Maryland soil fertility index values by using the formulas provided in University of Maryland Cooperative Extension Service publication SFM-4 (November 1996.) Appendix 3.1 also includes values for the 50 soil samples obtained from Chesapeake Forest Products.

3.E Results

The analyzed data for the soil samples are mostly self-explanatory. In and of themselves, the results would be of interest solely to the landowner or manager of the lands where each sample was taken. To give the data meaning, they must be compared to the fertility values of agricultural lands, and against Maryland nutrient management criteria for the application of fertilizers. This is what we have done in this study.

The simplest way to express a summary of the analyzed results would be to give an average value of each nutrient for all soil samples taken, and compare that average against State of Maryland benchmarks regulating fertilizer application. However, this approach would not adequately address the range of analysis values; nor would it describe how all the samples fell into that range.

3.E.1. Phosphorus

Research shows that one- to two-year-old pine trees can benefit from applications of phosphorus (Allen 1994). Maryland’s nutrient-management guidelines monitor soil phosphorus levels closely, and prior to any application of phosphorus fertilizer, a soil test must be performed to insure that soil phosphorus levels are not excessively high. The phosphorus levels of the soil samples taken are the most significant of all the data presented here. Figure 3.1 illustrates the distribution of phosphorus in the analyzed samples.

The vast majority of samples turned out to be in the “very low” and “low” index value categories developed by the University of Maryland for describing agricultural soils’ fertility levels. Rated “very low” were 160 samples, representing 55.2 percent of the 290 samples analyzed (our own 240 samples and Chesapeake Forest Products’ 50 samples). Another 86 samples rated “low” (29.7 percent). Combined, these “very low” and “low” phosphorus samples accounted for 246, or 84.8 percent, of all the samples reviewed by A&L’s laboratory.

Only 15.2 percent of the samples had a rating of “medium” or higher. These higher ratings indicated either a forested tract that had previously been used for crop production or one that had been fertilized as part of a forest-management plan, or both. Given that some of the stands where we found relatively high

Fig. 3.2

Distribution of Potassium Values within Eastern Shore Soils

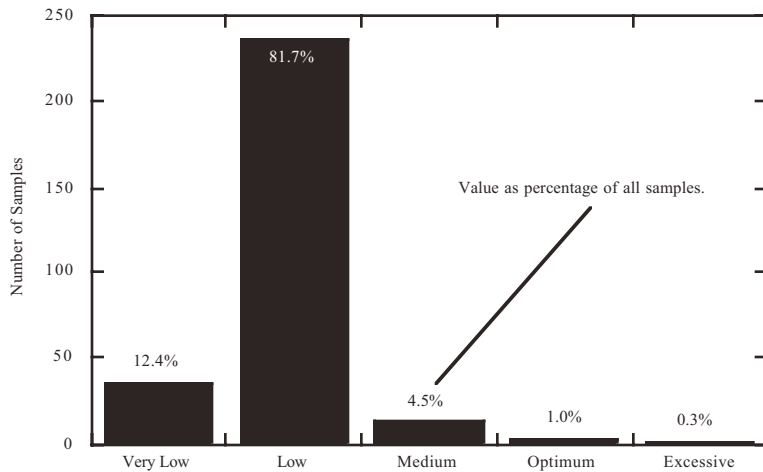


Fig. 3.3

Distribution of Magnesium Values within Eastern Shore Soils

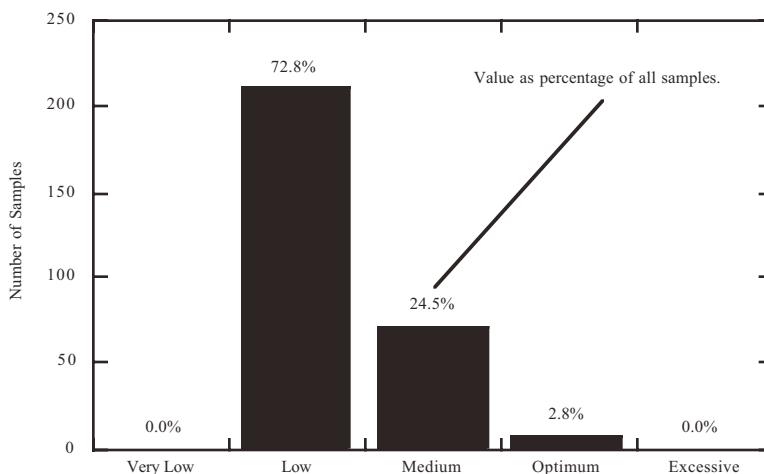
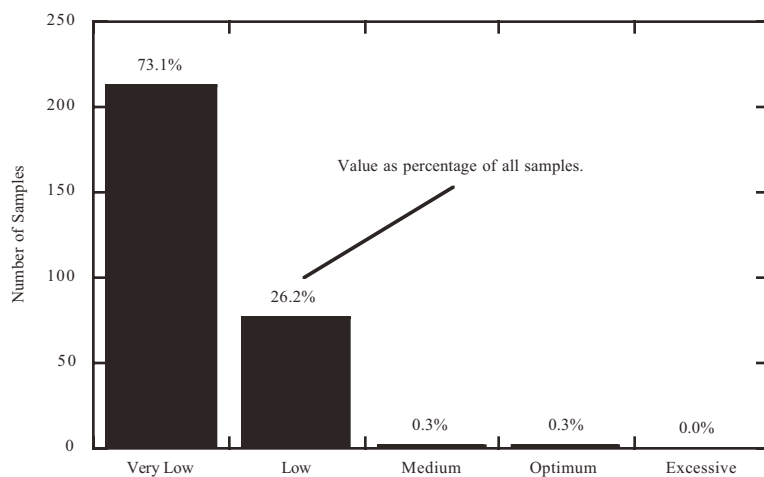


Fig. 3.4

Distribution of Calcium Values within Eastern Shore Soils



phosphorus counts were quite old, higher rated samples demonstrate that soils that have once been fertilized with phosphorus will retain high levels of phosphorus for up to 40 years after the cessation of fertilization. Appendix 3.2 shows the distribution of phosphorus in more detail.

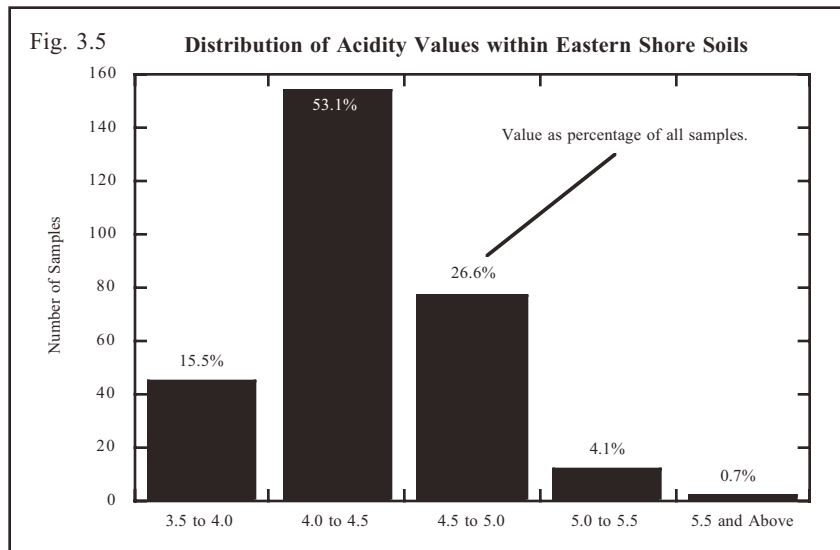
3.E.2. Potassium

While most food crops require soil potassium in substantial quantities, forests do not. Maryland does not monitor potassium levels or application rates in its state-mandated program for the control of nutrients. The distribution of potassium is given in figure 3.2, with the detailed distribution table appearing in Appendix 3.3.

Just about all of the 290 samples tested rated “very low” or “low,” 36 of the former (12.4 percent) and 237 of the latter (81.7 percent), for a combined total of 273 (94.1 percent). Only one of the samples (0.3 percent) rated “excessive” in potassium value.

3.E.3. Magnesium

Soil levels of magnesium were generally found to be in the “low” index category. No samples were found to have a “very low” value, nor were any found to have an “excessive” value. Almost three-fourths of the samples were in the “low” range (72.8 percent), with just about one-fourth in the “medium” range (24.5 percent). The remaining 2.8 percent had an “optimum” magnesium value. Not one soil sample produced an “excessive” magnesium reading.



Magnesium is considered a minor nutrient for crops, and little is known about its effect on forest growth. Figure 3.3 illustrates the distribution of magnesium, and Appendix 3.4 shows the distribution in detail in tabular format.

3.E.4. Calcium

Calcium is minor crop nutrient. Figure 3.4 gives the distribution of calcium within the sample group. Appendix 3.5 details the distribution. Suffice it here to say that virtually all the samples tested (99.3 percent) proved to have calcium values in the “very low” or “low” range.

3.E.5. Acidity

Acidity in the soil is measured by pH (the abbreviation for “negative 10-base log [power] of the hydrogen ion concentration”). Most soils on the peninsula have a natural pH of 3.8 to 5, and pH levels above that likely indicate that agricultural practices have made an impact on the soil. Forests are adapted to acidic soil conditions. The distribution of pH is depicted in figure 3.5, with the table of the distribution appearing at Appendix 3.6.

Over two-thirds of the soil samples, 68.6 percent, fell within the lower two pH groupings, that is, 3.5 to 4.0 and 4.0 to 4.5. Just over a quarter of the samples, 26.6 percent, were at the mid-range (pH 4.5 to 5.0). The remaining handful of samples, 4.8 percent, were in the higher ranges of 5.0 to 5.5 and 5.5 and above.

3.E.6. Nitrogen

Though nitrogen is a major component of fertilizer runoff into the bay, we did not test for its presence in our 290 soil samples. Nitrogen is an important element of the most important substances existing in plants. Even though nitrogen makes up 40 to 50 percent of the dry matter of plant protoplasm, the living substance of plant cells, it does not exist in a mineral form in soils as other plant nutrients do. The majority of nitrogen in soil is in the pore space (air), which is about 78 percent

nitrogen. The availability of that nitrogen to a plant during its growing period is closely related to plant available water, temperature, the physical and chemical status of the soil, and other environmental conditions. Thus, testing soils for nitrogen levels is difficult to accurately accomplish. Tests for soil nitrogen are usually taken when the plant being grown is expected to take up the nitrogen, and these tests are usually performed in the field; they are difficult to correlate from one site to the next.

3.F Conclusions

In evaluating the efficacy of applying poultry manure to managed forests, one must be mindful that, if any kind of fertilizer is to be applied to forests in Maryland, a certified nutrient-management plan must be developed and implemented. Regulations in the Maryland Water Quality Improvement Act of 1998 state: “An operator who uses biosolids or animal manure in an agricultural operation shall develop a nutrient management plan addressing nitrogen as the limiting nutrient on that agricultural operation by December 31, 2001, and shall implement the plan by December 31, 2002.... An operator who uses biosolids or animal manure in an agricultural operation shall develop a nutrient management plan addressing both nitrogen and phosphorus as the limiting nutrients on that agricultural operation by July 1, 2004, and shall implement the plan by July 1, 2005.”

Therefore, any forest manager applying poultry manure or any other fertilizer to forest lands must apply them in a matter consistent with the regulations of the State of Maryland's nutrient-management program. Applications of fertilizers to forests will likely be permitted under Maryland's nutrient management program, assuming that a certified nutrient-management plan is prepared for each site to be fertilized.

The majority of forested soils on Maryland's Eastern Shore have low levels of phosphorus and other soil nutrients. Given this, applications of fertilizers to these soils will improve pine growth. Some forested sites that have previously been in agronomic crops may display high levels of phosphorus and other soil nutrients, and may not meet Maryland's soil level thresholds for additional fertilizer application, but these soils should already be supplying enough nutrients for optimum tree growth. For most soils, however, and certainly just about all those soils never previously used for agricultural purposes, poultry litter should be an acceptable fertilizer for forest soils. Given these soils' low current nutrient content, they should more than adequately be able to absorb the nutrients occurring in raw chicken litter.

Most poultry litter application equipment broadcasts litter at rates that range from two to eight tons per acre. The average content of one ton of broiler poultry litter produced on the Shore is approximately 3 percent nitrogen, 3 percent phosphorus and 2 percent potassium. Applying two tons of litter would thus supply 120 pounds per acre of both nitrogen and phosphorus, which would likely be an adequate amount of fertilizer to stimulate pine growth. By applying some of the Shore's abundant supply of poultry litter to forests, two benefits are achieved: First, the Shore's second leading industry, forestry, is boosted by improving the growing conditions of its managed pine stands. Second, an alternative local disposal method is developed for poultry manure. Given the apparent willingness of Eastern Shore landowners — the sum total of whose names are included on the accompanying compact disk (see Appendix 3.7) — applying poultry manure to forest stands represents a rare win/win scenario for the Shore's two largest industries.



4. Appendices to Sections 1, 2 and 3

Appendices referred to in text

Seventeen pages of appendices follow and one page for notes.

Appendix 1.1

Landowner Willingness to Consider Chicken Litter Application, by Incentive Type and by County*

<i>Incentive Type</i>	<i>Caroline (n=49)</i>	<i>Dorchester (n=59)</i>	<i>Kent (n=24)</i>	<i>Q. Anne's (n=36)</i>
<i>Growth Only</i>	51%	41%	46%	58%
<i>Property Tax</i>	61%	61%	58%	75%
<i>Income Tax</i>	55%	56%	54%	72%
<i>Cost-Sharing</i>	49%	54%	67%	64%
<i>\$20 Payment</i>	29%	46%	50%	45%

<i>Incentive Type</i>	<i>Somerset (n=59)</i>	<i>Talbot (n=27)</i>	<i>Wicomico (n=76)</i>	<i>Worcester (n=72)</i>
<i>Growth Only</i>	73%	52%	58%	64%
<i>Property Tax</i>	78%	63%	64%	67%
<i>Income Tax</i>	71%	56%	62%	71%
<i>Cost-Sharing</i>	81%	63%	66%	67%
<i>\$20 Payment</i>	58%	48%	51%	56%

* This table presents raw data, without the econometric considerations described in section 2 of this report. This is to say, the table does not isolate those county-specific characteristics that might influence a respondent's willingness or lack of willingness to consider using poultry litter as a forest fertilizer. For example, if this table indicates that Somerset County residents are most agreeable to the use of poultry litter, this may be because they come from Somerset County, or it may be because the respondents from Somerset County happen to exhibit other characteristics that predispose them to look favorably upon poultry-litter use, such as age, income, acreage, etc. The econometric technique used in section 2 segregates all these characteristics, allowing us to determine the degree to which county of residence *alone*, or age *alone*, or income *alone* influence landowner attitudes. Where the data in this table differ from those in section 2, the section 2 data should be taken in preference to these.

Appendix 2.1

Means and Standard Deviations for Survey Sample*

<i>Variable</i>	<i>Mean</i>	<i>Standard Deviation</i>
<i>Owns more than 200 acres</i>	9.84%	0.2982093
<i>Owns between 101-200 acres</i>	21.86%	0.4138482
<i>Owns between 51-100 acres</i>	9.56%	0.2944836
<i>Somerset</i>	14.68%	0.3543136
<i>Wicomico</i>	18.91%	0.39204
<i>Worcester</i>	17.91%	0.3839176
<i>Owned land 5 years or less</i>	11.96%	0.3248985
<i>Owned land between 6-10 years</i>	11.70%	0.3218877
<i>Owned land between 10-20 years</i>	24.94%	0.4331963
<i>Owned land more than 20 years</i>	51.40%	0.5004412
<i>Has a forest management plan</i>	41.86%	0.4939689
<i>Has sold timber</i>	58.44%	0.49345
<i>Forester helped sell timber</i>	37.53%	0.4848151
<i>Sold within last 2 years</i>	11.14%	0.3150165
<i>Sold between 3-5 years ago</i>	12.66%	0.3329261
<i>Sold between 6-10 years ago</i>	10.89%	0.3118594
<i>Sold more than 10 years ago</i>	22.28%	0.4166428
<i>Likely to sell timber in the future</i>	48.45%	0.5004069
<i>Less than 10% of income from farm or forest mgt.</i>	21.70%	0.4128393
<i>Between 11-25% of income from farm or forest mgt.</i>	39.62%	0.4898864
<i>Between 26-50% of income from farm or forest mgt.</i>	10.38%	0.3054472
<i>Between 51-100% of income from farm or forest mgt.</i>	7.23%	0.2594369
<i>Owner/operator</i>	31.63%	0.4656363
<i>Less than 40 years old</i>	5.97%	0.2372282
<i>Between 40 to 59 years old</i>	38.06%	0.4861387
<i>60 years or older</i>	46.77%	0.4995749
<i>Male</i>	61.19%	0.4879155
<i>College Graduate</i>	37.37%	0.484413

* The means reported are based on the number of responses to each question. Some respondents declined to answer some of the questions.

Econometric Methodology

This analysis uses survey responses to determine landowner willingness to adopt poultry litter, employing an ordered response probit model. We can investigate similarities as well as differences among the landowners as to which land, farm or personal characteristics impact adoption preferences. By using a limited dependent variable model, the marginal contribution of each characteristic that affect respondents' willingness can be isolated.

Each landowner will experience benefits and costs from using poultry litter on his or her forest land. If a landowner perceives that the costs of using the litter exceeds the benefits in terms of increased growth and profit, he or she will not employ the manure as a fertilizer and *vice versa*. While exact benefits and costs are difficult to determine for each individual, using a stated preference approach, an individual'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. An individual's indirect utility function can be represented by $V_i(x_i, f)$ where x_i is the personal and land characteristics of the individual i and f is fertilizer use, with $f=0$ if no poultry litter is not used and $f=1$ if poultry litter is used. If the landowner is not using poultry litter, we assume that his or her indirect utility is $V_i(x_i, 0) > V_i(x_i, 1)$. 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 $V_i(x_i, 0) < V_i(x_i, 1, B)$ where B 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 levels that ensure $V_i(x_i, 0) < V_i(x_i, 1, B)$. If the incentive were sufficient to shift $V_i(x_i, 0) < V_i(x_i, 1, B)$, a landowner would say that he or she agrees to use poultry litter. The incentive level offered could result in a situation where $V_i(x_i, 0) = V_i(x_i, 1, B)$, and the owner might say that he or she did not know if s/he would use poultry litter. Similarly, if the level of incentive resulted in a situation where the costs remained larger than the benefits $V_i(x_i, 0) > V_i(x_i, 1, B)$, then a landowner would disagree and not use poultry litter. Different types of incentives were provided in the survey questions on willingness of parcel owner i to consider poultry litter use.

Since these discrete choices have a natural order (agree, do not know, disagree), an ordered-response model is used. If the true willingness is Y_i as a function of x_i , then $Y_i = \beta x_i + u_i$. The vector, x_i , includes personal and parcel characteristics for an individual (age, education, gender, geographic location, forest practices). The error is assumed to have a standard normal distribution so that $u_i \sim N(0,1)$. The true preference, Y_i , is not observed, but the stated preference on the survey question, y_i , can be used. The observed or stated preference is used as the dependent variable assuming that:

(Continued on next page.)

Econometric Methodology (Continued)

$$y_i = \text{disagree} = 0 \text{ if } \alpha_{-1} < Y_i \leq \alpha_0$$

$$y_i = \text{don't know} = 1 \text{ if } \alpha_0 < Y_i \leq \alpha_1$$

$$y_i = \text{agree} = 2 \text{ if } \alpha_1 < Y_i \leq \alpha_2$$

such that $\alpha_{-1} < \alpha_0 < \alpha_1 < \alpha_2$. The α '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 $\alpha_{-1} = -\infty$, $\alpha_2 = +\infty$, and anchor α_0 at zero. Y_i is assumed to be within the j th range if $\alpha_{j-1} < Y_i < \alpha_j$ ($j=0,1,2$). The $\text{prob}(y_i = j)$ is the probability that Y_i is in the j th range. Let $Z_{ij} = 1$ if Y_i is in the j th range, and $Z_{ij} = 0$ otherwise (Greene 1995).

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

$$\text{Prob}(Z_{ij} = 1) = \Phi(\alpha_j - \beta'x_i) - \Phi(\alpha_{j-1} - \beta'x_i) \quad (2)$$

where 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

$$L = \prod_i \prod_j [\Phi(\alpha_j - \beta'x_i) - \Phi(\alpha_{j-1} - \beta'x_i)]^{Z_{ij}} \quad (3)$$

and the log likelihood is

$$\log L = \sum_i \sum_j Z_{ij} \cdot \log [\Phi(\alpha_j - \beta'x_i) - \Phi(\alpha_{j-1} - \beta'x_i)] \quad (4)$$

No closed form solution exists; therefore the likelihood is maximized iteratively. We used Limdep 7.0 to maximize the likelihood, using an algorithm based on the method of Davidson, Fletcher and Powell (Fletcher 1980, Greene 1993).

References

- Fletcher, R. 1980. *Practical Methods of Optimization*. New York: Wiley.
- Greene, W.H. 1993. *Econometric Analysis*. 2nd ed. New York: Macmillan.
- Greene, W. H. 1995. *Limdep Users Manual, Version 7.0*. Econometric Software Inc.

**Willingness to Use Poultry Litter If Growth is Increased 20 Percent:
Regression Estimates for Ordered Probit Model (N=331)**

<i>Variable</i>	<i>Estimated Coefficient</i>	<i>Standard Error</i>
<i>Intercept #1</i>	-0.6537**	0.2678
<i>Intercept #2</i>	-0.3537	0.2666
<i>Owns more than 200 acres</i>	1.4365**	0.4115
<i>Owns between 101-200 acres</i>	0.2008	0.2647
<i>Owns between 51-100 acres</i>	0.2873	0.1892
<i>Somerset</i>	0.6957**	0.2387
<i>Wicomico</i>	0.3357*	0.1981
<i>Worcester</i>	0.1029	0.209
<i>Owned land between 6-10 years</i>	-0.0641	0.3051
<i>Owned land between 10-20 years</i>	0.0849	0.2582
<i>Owned land more than 20 years</i>	0.1933	0.2495
<i>Has a forest management plan</i>	-0.0977	0.1724
<i>Has sold timber</i>	0.2579	0.216
<i>Forester helped sell timber</i>	0.461	0.3436
<i>Sold between 3-5 years ago</i>	-0.406	0.3713
<i>Sold between 6-10 years ago</i>	-0.7534**	0.3597
<i>Sold more than 10 years ago</i>	-0.6564**	0.3393
<i>Likely to sell timber in the future</i>	0.0262	0.1643
<i>Owner/operator</i>	0.3376**	0.1715
<i>Less than 40 years old</i>	1.0592**	0.3769
<i>Between 40 to 59 years old</i>	0.5457**	0.1681
<i>Male</i>	0.1168	0.1588
<i>College graduate</i>	-0.0265	0.1565

**Willingness to Use Poultry Litter If Property Tax Reduction:
Regression Estimates for Ordered Probit Model (N=331)**

<i>Variable</i>	<i>Estimated Coefficient</i>	<i>Standard Error</i>
<i>Intercept #1</i>	0.1124	0.2788
<i>Intercept #2</i>	0.3408	0.2793
<i>Owns more than 200 acres</i>	0.8725**	0.3726
<i>Owns between 101-200 acres</i>	0.4536	0.2999
<i>Owns between 51-100 acres</i>	0.1188	0.1965
<i>Somerset</i>	0.5332**	0.2556
<i>Wicomico</i>	0.1843	0.2059
<i>Worcester</i>	-0.0629	0.2137
<i>Owned land between 6-10 years</i>	0.0817	0.3372
<i>Owned land between 10-20 years</i>	-0.3337	0.2738
<i>Owned land more than 20 years</i>	-0.1885	0.2653
<i>Has a forest management plan</i>	-0.0616	0.1799
<i>Has sold timber</i>	0.4907	0.3648
<i>Forester helped sell timber</i>	0.2328	0.2256
<i>Sold between 3-5 years ago</i>	-0.6781*	0.3881
<i>Sold between 6-10 years ago</i>	-0.6559*	0.378
<i>Sold more than 10 years ago</i>	-0.4142	0.361
<i>Likely to sell timber in the future</i>	0.1361	0.1709
<i>Owner/operator</i>	0.0733	0.1767
<i>Less than 40 years old</i>	0.9165**	0.4092
<i>Between 40 to 59 years old</i>	0.4064**	0.1745
<i>Male</i>	0.0946	0.1656
<i>College graduate</i>	-0.093	0.1632

**Willingness to Use Poultry Litter If Income Tax Reduction:
Regression Estimates for Ordered Probit Model (N=331)**

<i>Variable</i>	<i>Estimated Coefficient</i>	<i>Standard Error</i>
<i>Intercept #1</i>	-0.2793	0.2723
<i>Intercept #2</i>	-0.0367	0.2721
<i>Owns more than 200 acres</i>	1.1703**	0.4115
<i>Owns between 101-200 acres</i>	0.3868	0.2866
<i>Owns between 51-100 acres</i>	0.2224	0.1947
<i>Somerset</i>	0.3897	0.2397
<i>Wicomico</i>	0.2108	0.2032
<i>Worcester</i>	0.096	0.216
<i>Owned land between 6-10 years</i>	0.2428	0.3281
<i>Owned land between 10-20 years</i>	-0.1257	0.266
<i>Owned land more than 20 years</i>	0.0317	0.2575
<i>Has a forest management plan</i>	-0.0302	0.1778
<i>Has sold timber</i>	0.5208	0.3635
<i>Forester helped sell timber</i>	0.3206	0.2221
<i>Sold between 3-5 years ago</i>	-0.6531*	0.3923
<i>Sold between 6-10 years ago</i>	-0.6996*	0.3805
<i>Sold more than 10 years ago</i>	-0.5488	0.3595
<i>Likely to sell timber in the future</i>	0.089	0.1679
<i>Owner/operator</i>	0.1284	0.1755
<i>Less than 40 years old</i>	0.8825**	0.3717
<i>Between 40 to 59 years old</i>	0.6031**	0.1732
<i>Male</i>	-0.00316	0.1642
<i>College graduate</i>	0.00335	0.1619

**Willingness to Use Poultry Litter If Cost-Share Incentive Payment:
Regression Estimates for Ordered Probit Model (N=331)**

<i>Variable</i>	<i>Estimated Coefficient</i>	<i>Standard Error</i>
<i>Intercept #1</i>	-0.3631	0.2732
<i>Intercept #2</i>	-0.1907	0.2728
<i>Owns more than 200 acres</i>	1.3115**	0.4222
<i>Owns between 101-200 acres</i>	0.6125**	0.3089
<i>Owns between 51-100 acres</i>	-0.0587	0.1925
<i>Somerset</i>	0.6721**	0.2552
<i>Wicomico</i>	0.4116**	0.2091
<i>Worcester</i>	0.1163	0.2175
<i>Owned land between 6-10 years</i>	0.1376	0.3239
<i>Owned land between 10-20 years</i>	0.1706	0.2694
<i>Owned land more than 20 years</i>	-0.166	0.2567
<i>Has a forest management plan</i>	-0.284	0.1829
<i>Has sold timber</i>	0.2763	0.3486
<i>Forester helped sell timber</i>	0.3431	0.2286
<i>Sold between 3-5 years ago</i>	-0.3294	0.3728
<i>Sold between 6-10 years ago</i>	-0.3798	0.3674
<i>Sold more than 10 years ago</i>	-0.0299	0.3463
<i>Likely to sell timber in the future</i>	0.1224	0.1707
<i>Owner/operator</i>	0.216	0.1797
<i>Less than 40 years old</i>	1.0961**	0.4195
<i>Between 40 to 59 years old</i>	0.2641	0.1745
<i>Male</i>	0.2162	0.1648
<i>College graduate</i>	0.1175	0.1647

**Willingness to Use Poultry Litter If Per Acre Payment of \$20:
Regression Estimates for Ordered Probit Model (N=331)**

<i>Variable</i>	<i>Estimated Coefficient</i>	<i>Standard Error</i>
<i>Intercept #1</i>	-0.7585**	0.2608
<i>Intercept #2</i>	-0.4781*	0.2595
<i>Owns more than 200 acres</i>	1.038**	0.3084
<i>Owns between 101-200 acres</i>	0.0962	0.2541
<i>Owns between 51-100 acres</i>	0.2944	0.1841
<i>Somerset</i>	0.484**	0.2201
<i>Wicomico</i>	0.1888	0.1926
<i>Worcester</i>	0.1164	0.201
<i>Owned land between 6-10 years</i>	0.6453**	0.3016
<i>Owned land between 10-20 years</i>	0.3836	0.2477
<i>Owned land more than 20 years</i>	0.1436	0.2363
<i>Has a forest management plan</i>	-0.5825**	0.1724
<i>Has sold timber</i>	0.5887*	0.3127
<i>Forester helped sell timber</i>	0.3423*	0.2069
<i>Sold between 3-5 years ago</i>	-0.2135	0.3354
<i>Sold between 6-10 years ago</i>	-0.7321**	0.3272
<i>Sold more than 10 years ago</i>	-0.6188**	0.3043
<i>Likely to sell timber in the future</i>	0.9214**	0.3286
<i>Owner/operator</i>	0.3977**	0.161
<i>Less than 40 years old</i>	0.1242	0.1599
<i>Between 40 to 59 years old</i>	-0.0603	0.1618
<i>Male</i>	0.0318	0.1548
<i>College graduate</i>	0.0396	0.1521

Appendix 3.1a

**Individual Soil Sampling Results:
Eight Counties and Chesapeake Forest Products**

<i>Source</i>	<i>Chemical: Phosphorus</i>	<i>Index Value</i>	<i>Chemical: Potassium</i>	<i>Index Value</i>	<i>Chemical: Magnesium</i>	<i>Index Value</i>	<i>Chemical: Calcium</i>	<i>Index Value</i>	<i>Acid (pH)</i>
Worcester	0	Very Low	22	Very Low	54	Optimum	0	Very Low	3.8
Worcester	0	Very Low	0	Very Low	23	Low	0	Very Low	4.3
Worcester	0	Very Low	0	Very Low	24	Low	0	Very Low	4.3
Worcester	4	Low	0	Very Low	33	Medium	8	Low	4.2
Worcester	0	Very Low	8	Low	31	Medium	0	Very Low	4.7
Worcester	0	Very Low	11	Low	24	Low	0	Very Low	4.2
Worcester	0	Very Low	35	Medium	63	Optimum	1	Very Low	4.6
Worcester	0	Very Low	16	Low	33	Medium	0	Very Low	4.3
Worcester	176	Excessive	18	Low	61	Optimum	17	Low	5.7
Worcester	0	Very Low	7	Low	18	Low	0	Very Low	4.3
Dorchester	0	Very Low	0	Very Low	14	Low	0	Very Low	4.1
Dorchester	0	Very Low	0	Very Low	11	Low	0	Very Low	4.4
Dorchester	8	Low	3	Low	14	Low	0	Very Low	4.2
Dorchester	0	Very Low	3	Low	15	Low	0	Very Low	4.2
Dorchester	0	Very Low	32	Medium	47	Medium	0	Very Low	4.8
Dorchester	0	Very Low	39	Medium	52	Optimum	0	Very Low	4.8
Dorchester	0	Very Low	5	Low	19	Low	0	Very Low	4.2
Dorchester	0	Very Low	6	Low	21	Low	0	Very Low	4.1
Dorchester	0	Very Low	5	Low	19	Low	0	Very Low	4.2
Worcester	10	Low	23	Low	40	Medium	0	Very Low	4.7
Worcester	5	Low	25	Low	43	Medium	2	Low	4.8
Worcester	16	Low	22	Low	38	Medium	1	Very Low	4.8
Worcester	49	Medium	24	Low	52	Optimum	0	Very Low	4.3
Worcester	0	Very Low	23	Low	28	Medium	0	Very Low	4.4
Worcester	0	Very Low	23	Low	29	Medium	0	Very Low	4.4
Worcester	0	Very Low	23	Low	30	Medium	0	Very Low	4.6
Worcester	0	Very Low	12	Low	26	Low	0	Very Low	4.6
Worcester	29	Medium	0	Very Low	12	Low	0	Very Low	4.6
Worcester	10	Low	5	Low	14	Low	0	Very Low	4.3
Worcester	19	Low	0	Very Low	11	Low	0	Very Low	4.7
Worcester	0	Very Low	16	Low	28	Medium	0	Very Low	4.5
Worcester	11	Low	10	Low	26	Medium	0	Very Low	4.2
Worcester	0	Very Low	21	Low	24	Low	0	Very Low	4.4
Worcester	1	Low	8	Low	31	Medium	0	Very Low	4.8
Worcester	0	Very Low	7	Low	22	Low	0	Very Low	4.7
Worcester	0	Very Low	7	Low	20	Low	0	Very Low	4.7
Worcester	0	Very Low	6	Low	19	Low	0	Very Low	4.8
Worcester	0	Very Low	4	Low	19	Low	0	Very Low	4.6
Worcester	0	Very Low	5	Low	20	Low	0	Very Low	4.6
Worcester	0	Very Low	9	Low	22	Low	0	Very Low	4.6
Worcester	0	Very Low	11	Low	25	Low	0	Very Low	4.7
Worcester	0	Very Low	3	Low	21	Low	0	Very Low	4.7
Worcester	0	Very Low	3	Low	21	Low	0	Very Low	4.8
Worcester	0	Very Low	6	Low	21	Low	0	Very Low	4.7
Worcester	0	Very Low	7	Low	22	Low	0	Very Low	4.8
Worcester	0	Very Low	9	Low	21	Low	0	Very Low	4.7
Worcester	0	Very Low	9	Low	21	Low	0	Very Low	4.7

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Appendix 3.1b

<i>Source</i>	<i>Chemical: Phosphorus</i>	<i>Index Value</i>	<i>Chemical: Potassium</i>	<i>Index Value</i>	<i>Chemical: Magnesium</i>	<i>Index Value</i>	<i>Chemical: Calcium</i>	<i>Index Value</i>	<i>Acid (pH)</i>
Somerset	0	Very Low	18	Low	31	Medium	0	Very Low	4.3
Somerset	0	Very Low	19	Low	31	Medium	0	Very Low	4.2
Somerset	0	Very Low	17	Low	32	Medium	0	Very Low	4.2
Somerset	0	Very Low	20	Low	34	Medium	0	Very Low	4.3
Somerset	0	Very Low	12	Low	24	Low	0	Very Low	4.1
Somerset	0	Very Low	10	Low	23	Low	0	Very Low	4.1
Somerset	0	Very Low	10	Low	21	Low	0	Very Low	4.2
Somerset	0	Very Low	12	Low	23	Low	0	Very Low	4.2
Somerset	0	Very Low	13	Low	21	Low	0	Very Low	4.2
Somerset	0	Very Low	6	Low	20	Low	0	Very Low	4.1
Somerset	0	Very Low	7	Low	22	Low	0	Very Low	4.1
Somerset	0	Very Low	9	Low	27	Medium	0	Very Low	4
Somerset	0	Very Low	9	Low	23	Low	0	Very Low	4.1
Somerset	0	Very Low	9	Low	28	Medium	0	Very Low	4.1
Somerset	0	Very Low	9	Low	23	Low	0	Very Low	4.1
Somerset	0	Very Low	11	Low	26	Low	0	Very Low	4.3
Somerset	0	Very Low	12	Low	30	Medium	0	Very Low	4
Somerset	0	Very Low	9	Low	26	Low	0	Very Low	4.1
Somerset	0	Very Low	13	Low	27	Medium	0	Very Low	4.1
Somerset	0	Very Low	11	Low	25	Low	0	Very Low	4.1
Somerset	0	Very Low	9	Low	26	Medium	0	Very Low	4.2
Worcester	0	Very Low	3	Low	20	Low	0	Very Low	4.2
Worcester	0	Very Low	4	Low	22	Low	0	Very Low	4.1
Worcester	0	Very Low	4	Low	22	Low	0	Very Low	4
Worcester	0	Very Low	6	Low	21	Low	0	Very Low	4.1
Worcester	0	Very Low	5	Low	22	Low	0	Very Low	4.1
Worcester	0	Very Low	5	Low	22	Low	0	Very Low	4.2
Worcester	0	Very Low	3	Low	43	Medium	3	Low	5.2
Worcester	0	Very Low	3	Low	47	Medium	6	Low	5.2
Worcester	0	Very Low	5	Low	30	Medium	0	Very Low	4.4
Worcester	0	Very Low	0	Very Low	43	Medium	2	Low	5
Worcester	0	Very Low	1	Low	27	Medium	0	Very Low	4.2
Worcester	0	Very Low	2	Low	28	Medium	0	Very Low	4.3
Worcester	0	Very Low	0	Very Low	31	Medium	0	Very Low	4.9
Worcester	0	Very Low	1	Very Low	40	Medium	5	Low	5.1
Worcester	8	Low	0	Very Low	26	Low	0	Very Low	4.9
Worcester	5	Low	0	Very Low	31	Medium	0	Very Low	4.8
Worcester	0	Very Low	3	Low	30	Medium	0	Very Low	4.3
Worcester	0	Very Low	24	Low	30	Medium	0	Very Low	3.9
Worcester	0	Very Low	28	Medium	36	Medium	0	Very Low	3.9
Worcester	14	Low	18	Low	24	Low	0	Very Low	4.3
Worcester	0	Very Low	31	Medium	53	Optimum	0	Very Low	4.5
Worcester	0	Very Low	3	Low	26	Low	0	Very Low	4.1
Worcester	37	Medium	6	Low	25	Low	0	Very Low	4.2
Worcester	0	Very Low	7	Low	27	Medium	0	Very Low	4.1
Worcester	0	Very Low	15	Low	25	Low	0	Very Low	4.4
Worcester	0	Very Low	13	Low	24	Low	0	Very Low	4.5
Worcester	0	Very Low	14	Low	21	Low	0	Very Low	3.8
Worcester	0	Very Low	11	Low	29	Medium	0	Very Low	4.7
Worcester	0	Very Low	5	Low	30	Medium	0	Very Low	4.4
Worcester	0	Very Low	5	Low	27	Medium	0	Very Low	4.5

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Appendix 3.1c

<i>Source</i>	<i>Chemical: Phosphorus</i>	<i>Index Value</i>	<i>Chemical: Potassium</i>	<i>Index Value</i>	<i>Chemical: Magnesium</i>	<i>Index Value</i>	<i>Chemical: Calcium</i>	<i>Index Value</i>	<i>Acid (pH)</i>
Worcester	0	Very Low	0	Very Low	12	Low	0	Very Low	4.2
Worcester	0	Very Low	0	Very Low	14	Low	0	Very Low	4.2
Worcester	0	Very Low	1	Very Low	15	Low	0	Very Low	4.4
Worcester	0	Very Low	0	Very Low	15	Low	0	Very Low	4.4
Worcester	0	Very Low	0	Very Low	16	Low	0	Very Low	4.4
Worcester	0	Very Low	9	Low	25	Low	0	Very Low	3.5
Worcester	68	Optimum	0	Very Low	24	Low	2	Low	4.8
Worcester	56	Optimum	1	Very Low	27	Medium	0	Very Low	4.5
Wicomico	0	Very Low	0	Very Low	21	Low	0	Very Low	4.4
Wicomico	0	Very Low	2	Low	21	Low	0	Very Low	4.3
Wicomico	0	Very Low	5	Low	18	Low	0	Very Low	4.5
Wicomico	0	Very Low	5	Low	19	Low	0	Very Low	4.5
Wicomico	0	Very Low	7	Low	21	Low	0	Very Low	4.5
Wicomico	0	Very Low	4	Low	19	Low	0	Very Low	4.5
Wicomico	0	Very Low	4	Low	17	Low	0	Very Low	4.5
Wicomico	0	Very Low	5	Low	17	Low	0	Very Low	4.6
Wicomico	0	Very Low	12	Low	19	Low	0	Very Low	4.4
Wicomico	0	Very Low	5	Low	16	Low	0	Very Low	4.6
Wicomico	0	Very Low	7	Low	18	Low	0	Very Low	4.7
Wicomico	0	Very Low	5	Low	17	Low	0	Very Low	4.7
Wicomico	0	Very Low	13	Low	17	Low	0	Very Low	4.7
Wicomico	0	Very Low	9	Low	19	Low	0	Very Low	4.6
Kent	0	Very Low	3	Low	17	Low	0	Very Low	4.7
Kent	0	Very Low	5	Low	15	Low	0	Very Low	4.7
Kent	0	Very Low	3	Low	14	Low	0	Very Low	4.6
Kent	0	Very Low	11	Low	19	Low	0	Very Low	4.7
Kent	0	Very Low	9	Low	17	Low	0	Very Low	4.5
Kent	0	Very Low	4	Low	16	Low	0	Very Low	4.5
Kent	0	Very Low	5	Low	16	Low	0	Very Low	4.4
Kent	0	Very Low	9	Low	17	Low	0	Very Low	4.4
Kent	0	Very Low	9	Low	19	Low	0	Very Low	4.5
Kent	0	Very Low	3	Low	14	Low	0	Very Low	4.4
Kent	0	Very Low	5	Low	14	Low	0	Very Low	4.3
Kent	0	Very Low	2	Low	13	Low	0	Very Low	4.4
Kent	0	Very Low	1	Low	14	Low	0	Very Low	4.4
Kent	0	Very Low	5	Low	16	Low	0	Very Low	4.3
Kent	0	Very Low	4	Low	15	Low	0	Very Low	4.2
Kent	0	Very Low	3	Low	14	Low	0	Very Low	4.3
Kent	0	Very Low	8	Low	15	Low	0	Very Low	4.2
Kent	0	Very Low	7	Low	15	Low	0	Very Low	4.3
Kent	0	Very Low	0	Very Low	14	Low	0	Very Low	4.3
Kent	0	Very Low	3	Low	14	Low	0	Very Low	4.3
Queen Anne	64	Optimum	0	Very Low	17	Low	0	Very Low	4.5
Queen Anne	47	Medium	0	Very Low	17	Low	0	Very Low	4.6
Queen Anne	68	Optimum	0	Very Low	17	Low	0	Very Low	4.6
Queen Anne	86	Optimum	0	Very Low	17	Low	0	Very Low	4.8
Queen Anne	76	Optimum	1	Very Low	17	Low	0	Very Low	4.8
Queen Anne	109	Excessive	0	Very Low	18	Low	0	Very Low	4.8
Queen Anne	112	Excessive	0	Very Low	17	Low	0	Very Low	4.8
Queen Anne	163	Excessive	2	Low	18	Low	0	Very Low	5

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Appendix 3.1d

<i>Source</i>	<i>Chemical: Phosphorus</i>	<i>Index Value</i>	<i>Chemical: Potassium</i>	<i>Index Value</i>	<i>Chemical: Magnesium</i>	<i>Index Value</i>	<i>Chemical: Calcium</i>	<i>Index Value</i>	<i>Acid (pH)</i>
Queen Anne	109	Excessive	0	Very Low	19	Low	0	Very Low	4.6
Queen Anne	133	Excessive	0	Very Low	21	Low	0	Very Low	4.9
Queen Anne	169	Excessive	0	Very Low	20	Low	0	Very Low	4.9
Queen Anne	115	Excessive	0	Very Low	20	Low	0	Very Low	4.9
Queen Anne	155	Excessive	0	Very Low	23	Low	0	Very Low	5.1
Queen Anne	142	Excessive	0	Very Low	19	Low	0	Very Low	5
Queen Anne	151	Excessive	1	Very Low	22	Low	0	Very Low	5.1
Queen Anne	175	Excessive	0	Very Low	21	Low	0	Very Low	5.1
Queen Anne	181	Excessive	3	Low	21	Low	0	Very Low	5
Talbot	0	Very Low	5	Low	21	Low	0	Very Low	3.7
Talbot	0	Very Low	11	Low	22	Low	0	Very Low	3.7
Talbot	0	Very Low	11	Low	25	Low	0	Very Low	3.6
Talbot	0	Very Low	15	Low	28	Medium	0	Very Low	3.6
Talbot	0	Very Low	17	Low	35	Medium	0	Very Low	3.6
Talbot	0	Very Low	23	Low	38	Medium	0	Very Low	3.6
Talbot	0	Very Low	13	Low	33	Medium	0	Very Low	3.6
Talbot	0	Very Low	13	Low	26	Medium	0	Very Low	3.9
Talbot	0	Very Low	8	Low	23	Low	0	Very Low	4
Talbot	0	Very Low	5	Low	24	Low	0	Very Low	4
Talbot	0	Very Low	8	Low	24	Low	0	Very Low	4
Talbot	0	Very Low	13	Low	27	Medium	0	Very Low	4
Talbot	0	Very Low	11	Low	26	Low	0	Very Low	4
Talbot	0	Very Low	13	Low	27	Medium	0	Very Low	4
Talbot	0	Very Low	14	Low	24	Low	0	Very Low	4
Talbot	0	Very Low	8	Low	25	Low	0	Very Low	4
Talbot	0	Very Low	8	Low	21	Low	0	Very Low	4
Talbot	0	Very Low	4	Low	19	Low	0	Very Low	4
Talbot	0	Very Low	12	Low	21	Low	0	Very Low	4
Talbot	0	Very Low	11	Low	19	Low	0	Very Low	4
Talbot	0	Very Low	8	Low	19	Low	0	Very Low	4
Talbot	0	Very Low	11	Low	21	Low	0	Very Low	4
Talbot	0	Very Low	3	Low	18	Low	0	Very Low	4.1
Talbot	0	Very Low	3	Low	18	Low	0	Very Low	4
Talbot	0	Very Low	4	Low	19	Low	0	Very Low	4.1
Talbot	0	Very Low	9	Low	21	Low	0	Very Low	4.1
Talbot	0	Very Low	9	Low	20	Low	0	Very Low	4.1
Talbot	0	Very Low	7	Low	19	Low	0	Very Low	4
Talbot	0	Very Low	7	Low	20	Low	0	Very Low	4.1
Dorchester	0	Very Low	11	Low	40	Medium	0	Very Low	4.3
Dorchester	0	Very Low	2	Low	43	Medium	0	Very Low	4.2
Dorchester	0	Very Low	13	Low	38	Medium	0	Very Low	4.1
Dorchester	0	Very Low	8	Low	33	Medium	0	Very Low	4
Dorchester	0	Very Low	1	Low	32	Medium	0	Very Low	4
Dorchester	0	Very Low	3	Low	36	Medium	0	Very Low	4
Dorchester	0	Very Low	5	Low	33	Medium	0	Very Low	3.9
Dorchester	0	Very Low	8	Low	39	Medium	0	Very Low	4
Dorchester	11	Low	9	Low	28	Medium	0	Very Low	4
Dorchester	14	Low	8	Low	27	Medium	0	Very Low	4
Dorchester	20	Low	7	Low	27	Medium	0	Very Low	4.1
Dorchester	8	Low	3	Low	24	Low	0	Very Low	4.1
Dorchester	13	Low	3	Low	26	Low	0	Very Low	4.1

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Appendix 3.1e

<i>Source</i>	<i>Chemical: Phosphorus</i>	<i>Index Value</i>	<i>Chemical: Potassium</i>	<i>Index Value</i>	<i>Chemical: Magnesium</i>	<i>Index Value</i>	<i>Chemical: Calcium</i>	<i>Index Value</i>	<i>Acid (pH)</i>
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Caroline	5	Low	7	Low	24	Low	0	Very Low	4.4
Worcester	0	Very Low	30	Medium	36	Medium	0	Very Low	4.3
Worcester	0	Very Low	36	Medium	35	Medium	0	Very Low	4.3
Worcester	0	Very Low	23	Low	31	Medium	0	Very Low	4.2
Worcester	0	Very Low	23	Low	31	Medium	0	Very Low	4.1
Wicomico	34	Medium	26	Medium	8	Low	5	Low	4.7
Wicomico	27	Medium	15	Low	7	Low	5	Low	4.9
Wicomico	13	Low	10	Low	8	Low	4	Low	5
Wicomico	10	Low	14	Low	13	Low	5	Low	4.6
Wicomico	68	Optimum	11	Low	8	Low	5	Low	4.9
Wicomico	27	Medium	6	Low	7	Low	5	Low	3.8
Wicomico	26	Medium	10	Low	7	Low	5	Low	4.5
Wicomico	74	Optimum	13	Low	21	Low	19	Low	4.9
Wicomico	38	Medium	37	Medium	56	Optimum	67	Optimum	5.6
Wicomico	50	Medium	9	Low	58	Optimum	37	Medium	5.5
Wicomico	12	Low	10	Low	17	Low	8	Low	4.1
Wicomico	10	Low	11	Low	21	Low	6	Low	4.3
Wicomico	68	Optimum	7	Low	9	Low	5	Low	4.4
Wicomico	29	Medium	52	Optimum	7	Low	6	Low	4.4
Wicomico	9	Low	31	Medium	30	Medium	6	Low	3.6
Wicomico	13	Low	16	Low	11	Low	6	Low	4.4
Wicomico	26	Medium	12	Low	6	Low	7	Low	4.1
Wicomico	42	Medium	12	Low	5	Low	8	Low	4.3
Wicomico	17	Low	62	Optimum	29	Medium	11	Low	3.6
Wicomico	21	Low	65	Optimum	40	Medium	13	Low	3.6
Wicomico	30	Medium	7	Low	6	Low	5	Low	4.8
Wicomico	28	Medium	10	Low	6	Low	5	Low	4.8

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Appendix 3.1f

Source	Chemical: Phosphorus	Index Value	Chemical: Potassium	Index Value	Chemical: Magnesium	Index Value	Chemical: Calcium	Index Value	Acid (pH)
Chesapeake	52	Optimum	49	Medium	12	Low	8	Low	5.4
Chesapeake	39	Medium	3	Low	6	Low	4	Low	4.3
Chesapeake	23	Low	4	Low	7	Low	6	Low	4.6
Chesapeake	40	Medium	6	Low	6	Low	5	Low	4.8
Chesapeake	20	Low	32	Medium	8	Low	5	Low	5.2
Chesapeake	18	Low	16	Low	9	Low	4	Low	4.1
Chesapeake	15	Low	5	Low	8	Low	5	Low	4.3
Chesapeake	39	Medium	115	Excessive	8	Low	5	Low	5.1
Chesapeake	15	Low	16	Low	3	Low	7	Low	4.7
Chesapeake	16	Low	11	Low	5	Low	5	Low	4.4
Chesapeake	19	Low	11	Low	15	Low	6	Low	5.3
Chesapeake	12	Low	17	Low	10	Low	7	Low	5.1
Chesapeake	26	Medium	8	Low	14	Low	6	Low	4.7
Chesapeake	19	Low	24	Low	15	Low	6	Low	4.4
Chesapeake	19	Low	9	Low	4	Low	8	Low	4.8
Chesapeake	10	Low	20	Low	9	Low	8	Low	4.7
Chesapeake	22	Low	6	Low	4	Low	9	Low	4.4
Chesapeake	25	Low	12	Low	9	Low	8	Low	3.8
Chesapeake	139	Excessive	13	Low	6	Low	8	Low	5
Chesapeake	61	Optimum	14	Low	3	Low	7	Low	4.7
Chesapeake	16	Low	20	Low	12	Low	6	Low	4.6
Chesapeake	18	Low	29	Medium	17	Low	6	Low	4
Chesapeake	19	Low	12	Low	3	Low	8	Low	4.8
Chesapeake	13	Low	4	Low	3	Low	8	Low	4.8
Chesapeake	19	Low	20	Low	3	Low	7	Low	4.8
Chesapeake	8	Low	20	Low	19	Low	6	Low	4.6
Chesapeake	11	Low	21	Low	27	Medium	7	Low	4.6
Chesapeake	11	Low	13	Low	6	Low	3	Low	4.2
Chesapeake	10	Low	15	Low	8	Low	3	Low	4.2
Chesapeake	16	Low	20	Low	10	Low	2	Low	4.4
Chesapeake	11	Low	19	Low	5	Low	3	Low	4.4
Chesapeake	11	Low	27	Medium	14	Low	4	Low	4.3
Chesapeake	9	Low	22	Low	11	Low	4	Low	4.3
Chesapeake	14	Low	20	Low	5	Low	2	Low	4.1
Chesapeake	11	Low	22	Low	6	Low	2	Low	4.1
Chesapeake	8	Low	18	Low	27	Medium	2	Low	4.2
Chesapeake	8	Low	19	Low	21	Low	6	Low	4.2
Chesapeake	12	Low	17	Low	23	Low	6	Low	4.4
Chesapeake	8	Low	16	Low	24	Low	7	Low	4.3
Chesapeake	9	Low	13	Low	42	Medium	18	Low	4.8
Chesapeake	15	Low	15	Low	9	Low	3	Low	4.4
Chesapeake	15	Low	18	Low	8	Low	3	Low	4.3
Chesapeake	13	Low	17	Low	7	Low	2	Low	4.1
Chesapeake	13	Low	17	Low	11	Low	3	Low	4.3
Chesapeake	9	Low	17	Low	11	Low	3	Low	4.3
Chesapeake	7	Low	17	Low	13	Low	3	Low	4.3
Chesapeake	9	Low	17	Low	28	Medium	6	Low	4.4
Chesapeake	9	Low	16	Low	19	Low	5	Low	4.4

End of appendix 3.1.

Appendix 3.2

Distribution of Phosphorus Values within Eastern Shore Soils

<i>Maryland Index Category</i>	<i>No. of Samples</i>	<i>Percentage</i>	<i>Cumulative</i>
<i>Very Low</i>	160	55.17%	55.17%
<i>Low</i>	86	29.66%	84.83%
<i>Medium</i>	19	6.55%	91.38%
<i>Optimum</i>	11	3.79%	95.17%
<i>Excessive</i>	14	4.83%	100.00%

Appendix 3.3

Distribution of Potassium Values within Eastern Shore Soils

<i>Maryland Index Category</i>	<i>No. of Samples</i>	<i>Percentage</i>	<i>Cumulative</i>
<i>Very Low</i>	36	12.41%	12.41%
<i>Low</i>	237	81.73%	94.14%
<i>Medium</i>	13	4.48%	98.62%
<i>Optimum</i>	3	1.04%	99.66%
<i>Excessive</i>	1	0.34%	100.00%

Appendix 3.4

Distribution of Magnesium Values within Eastern Shore Soils

<i>Maryland Index Category</i>	<i>No. of Samples</i>	<i>Percentage</i>	<i>Cumulative</i>
<i>Very Low</i>	0	0.00%	0.00%
<i>Low</i>	211	72.76%	72.76%
<i>Medium</i>	71	24.48%	97.24%
<i>Optimum</i>	8	2.76%	100.00%
<i>Excessive</i>	0	0.00%	100.00%

Appendix 3.5

Distribution of Calcium Values within Eastern Shore Soils

<i>Maryland Index Category</i>	<i>No. of Samples</i>	<i>Percentage</i>	<i>Cumulative</i>
<i>Very Low</i>	212	73.10%	73.10%
<i>Low</i>	76	26.21%	99.31%
<i>Medium</i>	1	0.35%	99.66%
<i>Optimum</i>	1	0.34%	100.00%
<i>Excessive</i>	0	0.00%	100.00%

Appendix 3.6

Distribution of Acidity Values within Eastern Shore Soils

<i>Acidity (pH) Level</i>	<i>No. of Samples</i>	<i>Percentage</i>	<i>Cumulative</i>
<i>pH 3.5 to 4.0</i>	45	15.52%	15.52%
<i>pH 4.0 to 4.5</i>	154	53.10%	68.62%
<i>pH 4.5 to 5.0</i>	77	26.55%	95.17%
<i>pH 5.0 to 5.5</i>	12	4.14%	99.31%
<i>pH 5.5 and Above</i>	2	0.69%	100.00%

Narrative Description of Accompanying Compact Disk

On the compact disk (CD) released with this report, there are three directories: (a) MASTFL Text Files, (b) MASTFL Excel Spreadsheets and (c) Address Lists.

A. MASTFL Text Files: This directory contains the files obtained from the State of Maryland. They are ASCII text files that can be opened with any standard text viewer, such as Microsoft Windows Notepad. We have also included a file named MASTFL_Layout.txt. This file describes the data layout for the MASTFL files.

B. MASTFL Excel Spreadsheets: This directory contains the files converted to Microsoft Excel. They were created using Microsoft Excel 97 SR-2 and can be opened with any Microsoft Excel version 97 and above. The data in these files have been parsed using the MASTFL data layout information.

C. Address Lists: This directory contains the address lists used for the survey. They were created using Microsoft Excel 97 SR-2 and can be opened with any Microsoft Excel version 97 and above.

End of appendix section.