To the Graduate Council

I am submitting herewith a thesis written by Justin G. Gardner entitled "Marketing Implications Based on Contingent Valuation and Maximum Likelihood Estimates of Consumers' Willingness to Pay for Flowering Dogwoods that are Resistant to Powdery Mildew." I have examined the final paper copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Economics.

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Marketing Implications Based on Contingent Valuation and Maximum Likelihood Estimates of Consumers' Willingness to Pay for Flowering Dogwoods that are Resistant to Powdery Mildew

A Thesis
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Justin Greer Gardner
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Dedication

This thesis is dedicated to my wife

Leigh Ann Gardner

whose unconstrained love and support have provided me with unlimited utility.

Acknowledgments

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Abstract

Powdery mildew is a disease affecting flowering dogwoods which can limit growth, detract from the appearance, and may cause plant decline and death. The dogwood is an important source of revenue for Tennessee's landscape nursery industry and the landscape industry in general. The University of Tennessee has developed a series of dogwood trees that are resistant to powdery mildew and is considering their commercial introduction.

The feasibility of introducing a series of resistant trees depends to a large extent on consumer acceptance. Since the trees are not commercially available and growers require some indication of the demand before they are likely to produce the trees, estimates of the value consumers place on the disease-free trees are needed.

This report summarizes a study of consumers' willingness to pay, in Tennessee, Mississippi, and Michigan, for a powdery mildew resistant tree. The goal is to provide information about marketing strategies for the introduction of the new tree. It is addressed in three parts. The first is to estimate the willingness to pay. The second is to estimate the willingness to pay as a function of homeowner characteristics. Third, results of the estimation are used to draw marketing implications. Analysis is based on the contingent valuation approach, which asks respondents (consumers) how much they would be willing to pay for products under specified conditions. An extension involves comparisons among goods or services that have slightly different bundles of characteristics, and respondents are asked to indicate how much more they are willing to

pay. The present context is a comparison between a traditional dogwood tree, in a five gallon container, versus the same tree in terms of shape, size, and appearance, but powdery mildew resistant.

On average, survey respondents indicated that they are willing to pay a $13.35 premium for a dogwood tree, in a standard 5 gallon container, that is resistant to powdery mildew. It is also important to note that this premium was measured at the retail level and reflects a cumulative effect, so that each agent in the supply chain cannot expect to receive this premium. Regression results led to inferences that the following variables had significant effects on the willingness to pay: presence of dogwoods in the respondent's yard, presence of dogwoods infected with powdery mildew in the yard, landscape expenditures, presence of flower beds, landscape satisfaction, criteria for selecting plants and trees, retail outlets where respondents shop for landscape materials, geographic location, and income. Marketing implications include the need to provide information at the point of sale and to interact with shoppers to determine characteristics of their yards.

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Chapter 1: Introduction

Powdery mildew (*Microsphaera Pulchra*) is a fungal disease affecting flowering dogwoods (*Cornus florida*). Symptoms include disfigured leaves, stunted plant growth, limited flowering, and dead branches. Ultimately, powdery mildew can cause plant health decline and death. An infected tree is also more likely to develop insect, pest, and drought stress problems. Powdery mildew is difficult to control. Prevention and cure require repeated fungicide applications to maintain disease-free plants (Windham & Witte).

The dogwood tree is important to several groups in Tennessee. It is crucial to suppliers, such as nursery stock producers, distributors, and retailers. In 1998, Tennessee's nursery industry income from retail and wholesale dogwood sales was $6.1 million, and dogwoods made up 14.9 percent of the Tennessee wholesale and retail nursery sales (Tennessee Agricultural Statistics Service). Nationally, Tennessee was ranked first in nationwide dogwood sales in 1998 (Tennessee Agricultural Statistics Service), with 23.2 percent of the nation's wholesale and retail dogwood sales (U.S. Department of Agriculture). However, these figures understate the Tennessee dogwood industry. Many nurseries produce seedlings which are sold to out-of-state nursery growers. When these unfinished dogwoods are taken into account, six counties in the State supply 80 percent of the country's dogwoods (Simmons). These counties are Coffee, DeKalb, Franklin, Grundy, Warren and White (Windham 2). Therefore, powdery mildew threatens much of the nation's supply of dogwoods.

Powdery mildew increases growing and marketing costs for dogwood nursery stock producers and distributers. Costs are primarily due to the increased number of fungicide applications and the loss of trees. In 1984, the estimated cost of pest and disease control for one acre of flowering dogwoods was $290 over a three year period. For 2000, this estimate was approximately $1,075 per acre, with the increased cost largely due to powdery mildew (Klingeman et al.).

Dogwoods have been popular ornamental trees. Homeowners, new home builders, and professional landscapers have found this tree desirable due to its bright spring flowers and fall foliage (Figure 1.).

Figure 1. Healthy Dogwood Tree in Full Bloom.

The demand for dogwoods is likely to decline because of powdery mildew for two reasons. First, when designing new landscapes people could substitute other ornamental trees, such as the redbud, in place of a traditional dogwood that may contract powdery mildew. Homeowners seeking to add a new flowering tree, or replace a diseased dogwood, are likely to choose a substitute ornamental tree as well. Second, powdery mildew confronts homeowners who purchase a dogwood with the need to apply fungicides. Higher maintenance costs increase the total cost of purchasing and owning a dogwood. Economic theory suggests that the result of a decrease in both supply and demand is that price could increase, decrease or stay the same, depending on the elasticities of supply and demand and the magnitude of the change, and quantity exchanged will decrease. Therefore, it is important that resistant trees are developed.

The University of Tennessee has identified three dogwood varieties that are resistant to powdery mildew. Plant patent applications have been filed and are pending for what will be known as the Appalachian™ series. This new series will have at least four impacts on supply: 1) lower production cost due to reduced spraying, 2) lower production costs due to fewer trees becoming infected while being grown in the nursery, 3) additional learning costs to nurseries unfamiliar to the new variety, and 4) additional cost to recover the expense of developing the resistant trees. Depending on the magnitudes of the impacts of these effects the net impact on supply could be positive or negative.

The introduction of a resistant tree should increase demand for dogwoods. Buyers do not have to incur the risk of loss due to powdery mildew. Maintenance costs are also lowered due to a reduced need for spraying.

The feasibility of introducing a series of resistant trees depends to a large extent on consumer acceptance. Since the trees are not commercially available and growers require some indication of the demand before they are likely to produce the trees, estimates of the value consumers place on the disease-free trees are needed.

A study of consumers' willingness to pay in Tennessee, Mississippi, and Michigan for a powdery mildew resistant tree is described. The objectives are to: 1) estimate the mean willingness to pay, 2) estimate a regression equation to explain willingness to pay, and 3) develop marketing implications based on these estimates. Analysis is based on the contingent valuation approach, which asks respondents (consumers) how much they would be willing to pay for a product under specified conditions. In this context, it was a comparison between a traditional dogwood tree in a standard 5 gallon container versus the same tree in terms of shape, size, and appearance, but powdery mildew resistant. The question of interest was how much more one would pay for the resistant tree.

Chapter 2: Methodology

Willingness to Pay

Traditionally, consumer demand is considered to be a function of a person's ability and willingness to buy a quantity of a good or service (e.g. Eastwood). The former depends on the money budgeted and prices. The latter is derived from a consumer's preferences for the goods and services. The consumer's objective is to maximize utility, subject to a budget constraint, where the satisfaction derived from goods and services determines the willingness to trade, and money and prices determine the ability to trade. Maximization occurs where the consumer obtains the greatest utility, given market conditions and income. Traditional demand analysis models the quantity demanded as a function of income, prices, advertising (marketing), and demographics.

The resistant dogwood tree is not available on the market, so the demand for the tree cannot be estimated using sales and price data. An alternative approach is to ask people the amount of compensation required (change in income) to remain as well off in different situations. The amount is considered to be an estimate of the willingness to pay. With respect to dogwoods, the two situations are to purchase a nonresistant traditional tree versus an identical powdery mildew resistant tree. It was assumed that the consumer would get more utility from, and spend less maintaining, the resistant tree and, therefore, would be willing to pay more for the tree. The setting involves considerations of the willingness to pay for a resistant tree, or a contingent valuation. The respondent is asked

to reveal the value of the disease resistance in such a way that the person is just as well off, regardless of which tree is actually purchased.

There has been much debate as to how a survey should ask the willingness to pay question (e.g., Bishop and Heberlein; Whittington et al.; Mitchell and Carson; Rowe Schulze, and Breffle). Often a price, called a bid, is given, and the respondent is asked if he or she would pay more or less than this price. This method has been called a bidding game. It can be followed with either an inquiry as to how much more or less the respondent is willing to pay, or with subsequent bids. Much of the debate on this method centers on whether the amount of the initial bid causes a starting point bias (Bishop and Heberlein).

Using the payment card method, sometimes called the bidding card method, reduces the potential of starting point bias. It is common for a payment card to be anchored, where prices for similar goods or services are placed on the card for reference points. A potential drawback of an anchored payment occurs when there is price variation among retailers, making it difficult and awkward to create a single reference price setting. Additionally, the anchors on the card could lead the respondent to an answer, causing a bias. An unanchored payment card, where the respondent is asked to choose a willingness to pay amount within a specified range, was developed in order to solve these problems.

One criticism of the contingent valuation method in general is the possibility for strategic bias (e.g., Whittington et. al.). Strategic bias occurs when a respondent, in an attempt to increase the likelihood that a good will be brought to market, will overstate his

or her willingness to pay. It is also possible for a respondent to understate willingness to pay in an attempt to lower the market price. Strategic bias is rare in contingent valuation studies, but "the possibility of strategic bias must be taken seriously"(Mitchell and Carson, 238). According to Whittington et al. (298) "most of the available evidence from the United States and Western Europe fails to support the hypothesis that individuals will act strategically in answering contingent valuations questions..." With respect to dogwoods and powdery mildew, there is little for the individual to gain from acting strategically, and no one individual could influence the survey just as an individual cannot influence the market.

Range bias is more likely to occur when the payment card range is either too large or too small. The respondents might not find their actual willingness to pay within the specified range if it is too small, thus affecting the willingness to pay mean and standard deviation. "Range bias may also result if a larger than necessary range encourages the reporting of spuriously high willingness to pay values that, while not affecting the remainder of the willingness to pay distribution, can bias upward the mean willingness to pay" (Rowe, Schulze and Breffle, 181). Examining the distribution of willingness to pay could reveal these biases. If there is a problem, the upper or lower tails could contain a large number of observations or there may be a tendency for respondents to pick the middle value, a centering bias.

One other potential source of bias is due to substitution effects (Cummings, Ganderton and McHuckin; Hoehn; Hoehn and Loomis; Kahneman and Knetsch). That is, a respondent's willingness to pay could be affected by substitutes and complements. To

the extent they are systematically omitted from the decision making, estimates of the willingness to pay would be biased. As explained below such a bias is not considered to be present because alternative landscape trees are promoted where the sampling took place.

Display

A display was designed for use in a booth at a home and garden show. The objective of the display was to inform visitors of the powdery mildew problem. A brief, non-technical explanation of the disease, in large, easy to read text, helped visitors to understand the powdery mildew problem quickly. Pictures at the display served to visualize the effects of powdery mildew. These included a large flowering dogwood in full bloom (Figure 1.), a close-up of healthy dogwood leaves, and a close-up of diseased dogwood leaves (Figure 2.). The display materials were intended to enable people to identify powdery mildew on their own dogwoods. Master Gardeners[1] or State Extension personnel were available to answer questions. After viewing the information presented, individuals were asked to complete a questionnaire.

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[1]A volunteer who has taken part in Extension Service horticulture training, for example 35 hours at the University of Tennessee (Sams).

Figure 2. Healthy and Diseased Dogwood leaves

Questionnaire

The questionnaire had three parts: (1) a willingness to pay setting; (2) landscape questions, which gathered data on the type of yard, landscape elements present in the yard, awareness and knowledge about tree and shrub diseases and pests; and (3) demographic questions which gathered socioeconomic data on the respondents. Appendix A contains the questionnaire.

The first part of the survey began with a statement to create the willingness to pay setting. The respondent was asked to assume that his or her favorite retailer was selling dogwood trees of uniform size in the standard five gallon container; the trunks were one inch in diameter, and height was five feet. Question 1 asked the respondent how much more he or she was willing to pay for an identical dogwood tree, except that it was resistant to powdery mildew. The respondent was then provided a range of values, starting at $0 and ending at $30, increasing by $1 increments. Although not stated in the

survey, the range was based on an expected price of a nonresistant dogwood tree being between $50 and $100 dollars, depending on the type of retailer. In this way the range on the payment card was designed to cover the likely range of responses, similar to the method suggested by Cameron and Huppert. In addition, the range used, $0 to $30, was to cover likely production costs, such as learning how to work with a new variety, providing a return to the University of Tennessee Experiment Station, and the cost of certification.

In the second section, most questions prompted the respondent to check items from a list, or rank items in a list. These items were designed to discover the characteristics of the respondent's landscape (Questions 2-6 and 8); expenditures on landscaping (Questions 5 and 6); knowledge of landscaping (Questions 7,9,12 and16); criteria for selecting trees and shrubs (Questions 10 and 13); where plants were purchased (Question 14); opinions about quality of plants purchased (Question 15); and opinions about pesticide use (Question 11).

The socioeconomic measures that were gathered reflected a trade-off between the length of the questionnaire, time required for completion, and a desire to obtain data on both landscape and respondent characteristics. An additional consideration was an interest in avoiding too few observations in some response categories by trying to gather too much detail from a limited sample. The socioeconomic information gathered included homeownership, age, sex, and income before taxes.

Survey Method

Booths were set up at four lawn and garden shows. The University of Tennessee Extension service had booth space at two shows, one in Knoxville, Tennessee, and the other in Nashville, Tennessee. Michigan and Mississippi Extension Services made similar arrangements in Detroit, Michigan and Jackson, Mississippi. Booths were staffed by master gardeners who chose survey respondents at random. The specific home and garden shows were selected for several reasons: 1) availability of both space 2) geographic dispersion and 3) availability of local staff to conduct the survey.

People attending a home and garden show comprise a desirable target population from which to draw a sample, given the present interest in deriving an estimate of the willingness to pay for a variety of dogwood that is not currently available in the market place. These shows are where consumers can gather information about landscape products they are interested in buying. For example, a renter is a member of the general population, but he or she is not likely to be in the market for a dogwood tree. Where would this renter plant the tree? On the other hand, a homeowner is more likely to be in the market for a tree. By collecting the sample at home and garden shows, one can focus on consumers who are in the market for landscape elements.

The setting also helped to mitigate substitution bias because many types of plants, trees and yard care alternatives are on display at these shows. Therefore, the setting is appropriate for estimating the willingness to pay for the resistant tree.

Modeling the Willingness to Pay

The additional price a respondent is willing to pay for a powdery mildew resistant dogwood is the dependent variable which is assumed to be a function of measures associated with responses to other questions in the survey. Willingness to pay is assumed to be normally distributed. However, the limited payment range represents a double-censored dependent variable. The range is bounded on the upper end by $30, and the lower by $0. When a respondent indicated a willingness to pay of an additional $30 for the resistant tree, it could mean one of two things. The respondent was either willing to pay a premium of exactly $30, or he or she would pay more than $30. In this way all willingness to pay figures greater than $30 are censored. On the lower bound, a willingness to pay of $0 could mean the respondent was not willing to pay a premium in this situation, he or she would never pay more in any situation, or to purchase a new variety the person would pay less to cover the risk that the new variety could develop other problems.

When estimating a regression equation with a dependent variable that is limited in this way, the standard method, called ordinary least squares (OLS), is not valid. Therefore, an alternative estimation technique must be used. Maximum likelihood is the appropriate estimator in this case. The objective of maximum likelihood is to estimate an equation that will maximize the likelihood of generating the observed willingness to pay. Constraints are placed on the likelihood function to restrict the range of values of the

dependent variable, which in the present case are $0 and $30 (Greene). Appendix B derives the equation that is used to estimate the willingness to pay.

Chapter 3: Results

Survey participants completed 610 questionnaires: 147 from Knoxville, Tennessee; 269 from Nashville, Tennessee; 132 from Detroit, Michigan; and, 62 from Jackson, Mississippi. The master gardeners staffing the booths did not report any data on the number of people asked to complete a questionnaire, therefore, the response rate is unknown. Descriptions of the data and univariate and pairwise tests of independence among responses to the questions are available elsewhere (Klingeman et al.). The discussion below presents characteristics of the respondents, landscape characteristics, and awareness and knowledge of disease and pest problems.

Descriptive Statistics

Characteristics of the respondents are displayed in Table 1. They were typical of people expected to attend home and garden shows and were similar to those found in other surveys of landscape plant buyers (e.g., Safley, Wohlgenant and Rezitisl; Barton et al., Hudson et al. and Hardy et al.). Almost all were homeowners. The percentage of respondents who owned their own homes ranged from a low of 92 percent in Knoxville to 98 percent in Jackson. The typical respondent had a higher income than the population as a whole. The median incomes in the four samples were $60,500 for Knoxville, $67,250 for Nashville, $69,750 for Detroit and $63,750 for Jackson. For 1999 the median incomes in Tennessee, Michigan, and Mississippi were $36,536, $46,238 and $32,450,

Table 1. Descriptive Statistics

	Knoxville, Tennessee	Nashville, Tennessee	Detroit, Michigan	Jackson, Mississippi
Number of Respondents	147	269	132	62
Homeownership (percentage)	92	95	94	98
Respondent's Median Income	$60,500	$67,250	$69,750	$63,750
Median Income for State[1]	$36,536	$36,536	$46,238	$32,450
Respondents's Median Age	50.7	49.8	53.2	51.1
Median Age for MSA	37.3[2]	34.5[2]	35.5[3]	33.0[4]
Existing Dogwood in Landscape (percentage)	86	80	47	72
Powdery Mildew Present in Landscape (percentage)	16	29	7	16
Average Annual Landscape Expenditures[5]	$886	$1,058	$973	$552

[1]U.S. Census Bureau; "Median Household Income by State: 1984 to 1999;" <http://www.census.gov/hhes/income/histinc/h08.html>: (accessed: 21 June 2001)

[2]U.S. Census Bureau; "Profiles of General Demographic Characteristics 2000 Census of Population and Housing Tennessee;" 2kh47.pdf; published May 2001; <http://www.census.gov/prod/cen2000/index.html>.

[3]U.S. Census Bureau; "Profiles of General Demographic Characteristics 2000 Census of Population and Housing Mississippi;" 2kh28.pdf; published May 2001; <http://www.census.gov/prod/cen2000/index.html>.

[4]U.S. Census Bureau; "Profiles of General Demographic Characteristics 2000 Census of Population and Housing Michigan;" 2kh26.pdf; published May 2001; <http://www.census.gov/prod/cen2000/index.html>.

[5]Among respondents who indicated landscape expenditures during 1999.

respectively (U.S. Census Bureau 2001a). Given the costs of owner-occupied housing, the prevalence of higher income respondents was not unexpected.

Respondents were generally older than the corresponding population. The median ages of respondents in the four samples were 50.7, 49.8, 53.2 and 51.1 for Knoxville, Nashville, Detroit, and Jackson, respectively, versus median population ages for the metropolitan statistical area (MSA) of 37.3 in the Knoxville MSA, 34.5 in the Nashville MSA, 33.0 in the Jackson MSA, and 35.5 in the Detroit MSA (U.S. Census Bureau 2001b,c,d). An older age distribution, for the sample versus the population, is consistent with the need to accumulate sufficient savings to at least make the down payment on a housing unit.

Landscape characteristics can give insight into the tastes and preferences of respondents. The majority of the respondents in the three southern areas already had dogwoods in their landscapes (86 percent in Knoxville, 80 percent in Nashville, and 72 percent in Jackson). In Detroit 47 percent of respondents indicated the presence of dogwoods in their landscapes. This pattern seems logical, as dogwoods are more suited to warmer climates.

At least 63 percent of the respondents in each city indicated that they had some pest or disease problems with the dogwoods in their landscapes. Powdery mildew was reported in 16 percent of Knoxville's dogwoods, 29 percent of Nashville's, 7 percent of Detroit's, and 16 percent of Jackson's. Their differences are statistically significant (Klingeman et al.). The low occurrence of powdery mildew in Detroit is likely a result of the climate since powdery mildew survives better in warmer climates (Windham).

Respondents were asked to estimate their annual expenditures in 11 yard-related categories (see Question 5 in the appendix). These were summed by respondent to obtain an estimate of a household's overall landscape expenditures. The average annual expenditure per lawn and garden show ranged from a low of $552 in Jackson to a high of $1,058 in Nashville.

A variety of other factors may have influenced willingness to pay for powdery mildew resistant dogwoods. The type of outlet where a respondent purchased trees could be related to willingness to pay. Price by outlet type and, therefore, willingness to pay, varies. One reason why price variation exists among outlet types is because the total cost of a good to a consumer is more than the retail price. Other components of the total cost to a consumer include time spent traveling and shopping, the cost of travel, the level of service provided by the retailer, and the cost of transporting the products from the retailer to the home. Additionally, the consumer's total cost includes the extra cost of maintaining a healthy non-resistant dogwood.

Independent garden centers, retail chains, nurseries, and mail order businesses were the top retail outlets in all four cities. Some of the respondents (16 percent in Knoxville, 24 percent in Nashville, 33 percent in Detroit, and 13 percent in Jackson) indicated that they purchased landscape plants from farm markets or truck stands, which were statistically significant difference's across cities (Klingeman et al.). Respondents typically reported that the quality of landscape plants purchased was good, regardless of the type of retail outlet.

Over half of the respondents (54 percent in Knoxville, 58 percent in Nashville, 64 percent in Detroit, and 50 percent in Jackson) have annual flower beds in their landscapes. In Knoxville, Nashville, Detroit and Jackson, 32 percent, 41 percent, 52 percent, and 43 percent of respondents, respectively, were content with their landscapes.

Question ten prompted the respondent to indicate why he or she chose landscape trees. Of particular interest to this study was disease resistance which was reported as important by 22 percent of all respondents. The top reasons for selecting trees were reported as size/shape, ease of maintenance, attracts birds/animals, flower color, and flowering season. Responses for this partial list are summarized in Table 2.

Table 2. Reasons to Select Trees for Landscape Use

Factor	Knoxville (n=147)	Nashville (n=269)	Detroit (n=132)	Jackson (n=62)	Combined (n=610)
Size/Shape [1]	51	48	61	40	51
Ease of Maintenance	47	43	44	42	45
Attracts Birds/Animals	37	31	38	32	34
Flower Color	30	35	32	37	33
Flowering Season	35	31	32	35	32
Disease Resistance	20	22	24	23	22

[1] Significantly different across cities at the 0.5 level, chi-square = 8.67.

Willingness to Pay

The goal of estimating the regression equation was to identify determinants of respondents' willingness to pay more for the resistant dogwood. Figure 3 shows the distribution of willingness to pay, the dependent variable, by percentage of respondents. Eight respondents indicated that they would not pay more for the resistant tree, and 45 respondents did not answer the willingness to pay question. Together these made up less than 10 percent of the observations. Less than 10 percent (56 respondents) claimed that they would pay $30 or more for the resistant tree.

Observations where respondents did not answer the willingness to pay question were treated as responses of $0 for estimation purposes. Often observations such as these are excluded when estimating a model. There are at least two drawbacks to doing so.

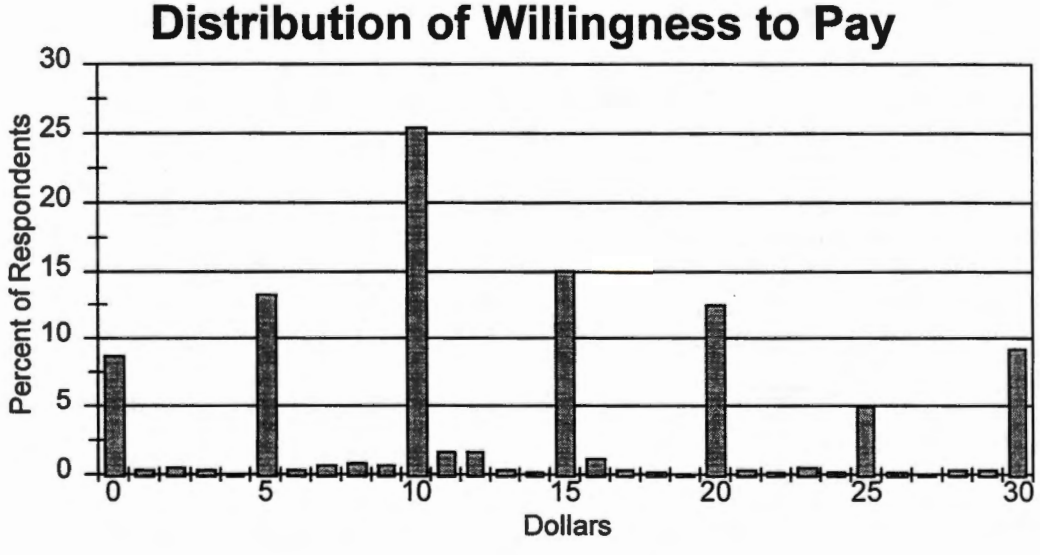

Figure 3. Distribution of Respondents' Willingness to Pay

First, the sample size would be reduced. Second, if these observations are significantly different from the rest of the sample, their omission may introduce a selection bias (e.g., Edwards and Anderson; Wang). The assumption is that a nonresponse reflects one of two possibilities. First, the respondent considered the problem to be unimportant, or second, the two trees in question were so similar that the respondent could not determine willingness to pay. In either case the willingness to pay would be zero. Implicit in this coding is the assumption that nonresponses to the payment question were not considered to be any form of protest, which seems reasonable because no public policy choices were involved.

There was a tendency for responses to cluster in multiples of five dollars, which were the values actually listed on the survey. The mean and standard deviation were $13.35 and $8.43 respectively, while the most common response was $10.00. Respondents could only indicate willingness to pay amounts in integers. However, the dependent variable was considered to be continuous because if the resistant dogwood was available on the market it would not have to be priced in dollar increments. Additionally, the dependent variable was assumed to be normally distributed.

The distribution of willingness to pay was checked for range bias. Each tail did not contain large proportion of the observations, and the median and mode was not in the center of the range. Therefore it appears that the range used was appropriate.

Independent Variables

Having a dogwood in the landscape (Question 3) was coded as a dummy variable: 1 = presence, 0 = absence. Its impact could be either positive or negative. One possibility was that respondents who already owned a dogwood could be less likely to purchase another one, let alone the resistant tree, so in this situation the variable's coefficient would be negative. Alternatively, if the variable's coefficient is positive, the conclusion would be that respondents who already own a dogwood understood the cost of preventing powdery mildew. Therefore, direction of causality is an empirical issue. There were 446 respondents who had dogwoods in their yards, and 164 did not.

Question 4 listed several diseases and problems that may be present in dogwoods, or associated with dogwoods. This list included drought injury, dogwood anthracnose, dogwood borer injury, and powdery mildew. It was expected that when powdery mildew was present, willingness to pay for a resistant dogwood would increase. For the remaining dogwood-specific problems, it was expected that the presence of the item would increase willingness to pay, the assumption being that respondents who have dogwoods with one of these problems would be more likely to be in the market for a new tree. There were 120 who indicated the presence of powdery mildew and 141 who indicated the presence of additional problems.

The sum of the 11 types of landscape expenditures listed in Question 5 was used in the regression for two reasons. First, the total landscape expenditure gives a better overall picture of the respondent's landscape than does any single item. Second, many

respondents only indicated expenditures on just a few of the items listed. This was the only variable that was not a dummy variable. As landscape expenditures increased, willingness to pay was expected to increase. There were 96 respondents who did not answer the question. Expenditures ranged from $0 to $24,333 with a mean expenditure of $803.

Landscape characteristics (Question 6) were coded as 1 equals the presence of and 0 equals the absence of each item. There was no *a priori* expectation as to which of these variables may have affected willingness to pay or the direction of causality. The coding did not affect the number of observations used in the regressions.

Question 7 gathered information about who identified and treated pests and diseases on landscape trees, plants, and shrubs. Each item was coded so that a value of one was assigned if the item was checked, and a value of zero was assigned to blank items. It was expected that respondents who used a commercial service would be willing to pay more for the resistant tree. These people would be able to reduce their lawn care costs in the future through the purchase of the resistant tree. There were 54 respondents who used a commercial service to identify pests and disease, and 72 used a commercial service to control them.

Question 8, satisfaction with the appearance of the landscape, was coded so that a "no" response was assigned a value of zero, and a "yes" a value of one. Respondents who were satisfied with their landscapes were hypothesized to be willing to pay less for a resistant dogwood. There were 243 respondents who were satisfied with their landscape.

Question 9 asked respondents if they regularly read gardening magazines. It was expected that respondents who did so would be more aware of landscape diseases and, therefore, be willing to pay more for the resistant tree. There were 391 respondents who claimed to read gardening magazines regularly.

Question 10 prompted the respondents to rank the top 5 reasons for selecting landscape trees. Many respondents, however, simply checked 5 items. Each reason was coded as a dummy variable: a zero meant the respondent had not ranked or checked the respective item, and a one represented it having been checked or ranked. Criteria that are associated with dogwoods (e.g., flowering) were expected to have positive coefficients, and criteria that are not (e.g., fruit) were expected to have negative coefficients. Disease resistance was expected to be significant and positive because respondents who prefer landscape plants that are resistant to disease are more likely to pay more for a disease resistant dogwood tree. Table 2 lists some of the most popular reasons to select trees. There were 146, 84, and 63 respondents that selected trees for disease resistance, flowering, and fruit respectively.

Question 11 asked respondents how much landscape injury they felt would be acceptable if they were able to reduce pesticides. Respondents could chose one of four options: high, moderate, low, or none. High was assigned a value of one, and none a value of four. The expectation was that the greater the damage the respondent would accept due to pesticide reduction, the more he or she would be willing to pay for the resistant dogwood. There were 44 respondents who would accept no landscape damage

due to pesticide reduction, 232 indicated low damage, 254 indicated moderate damage and 31 would accept high damage in order to reduce pesticide use.

Question 12 gathered information on the respondent's knowledge of integrated pest management. Eleven terms were listed, and the respondent indicated a level of familiarity with each. "Never heard of it" was coded as zero. The other three responses reflected at least some awareness of the respective term and were converted to one. This coding was used to distinguish between respondents who were unaware of the respective term versus those who had at least heard of it. Respondents who left a term or concept blank were considered to have never heard of it. It was hypothesized that individuals who have heard of the term or concept in question would be willing to pay more for a resistant dogwood. Urban landscape and organic gardening were the two most well known terms with 530 and 533, respectively, of the respondents indicating at least some familiarity with the terms. Insecticide resistance and pheromone trapping were the least familiar terms with 164 and 254 respondents indicating at least some familiarity with the terms.

Question 13 prompted the respondent to indicate his or her reasons for selecting landscape shrubs, perennials and annuals. Variables were coded as 0 for no response and 1 for a positive selection criteria. Because this question did not specifically deal with trees, there were no *a priori* expectations as to significance or sign. The coding did not affect the number of observations.

Question 14 listed eight types of retail outlets, which were converted to eight dummy variables, where a 0 (1) meant that the respondent did not (did) shop for

landscape trees and plants at a particular location. The two most popular retail outlets were farm markets or truck stands, with 385 respondents, and independent or specialty garden center, with 372 respondents. Respondents could have indicated more than one from this list.

Question 15 asked the respondents about the quality of landscape plants that they had purchased. Not sure was assigned a value of zero. The next four choices (excellent, good, mediocre and poor) were assigned a value between one and four, where excellent was four, and poor was one. There were no *a priori* expectations as to the sign of this variable's coefficient. It could be that those who were dissatisfied might be willing to pay more for the resistant tree, or given their perceptions of quality, the person would not be willing to pay more. The majority of respondents rated the quality of the plants and trees they had purchased as good (413) or excellent (58).

Question 16 asked the respondent to name a beneficial insect, bird, and plant. This was coded as a dummy variable where one was given if the respondent could name at least one. The purpose of this question was to assess the respondent's level of landscape knowledge. It was assumed that if a person named at least one, then he or she would possess a higher level of landscape knowledge than someone who could not do so and, therefore, be willing to pay more for the resistant dogwood tree. There were 439 respondents who could name at least one beneficial organism.

For Question 17, gender, male was assigned a value of one, and female was assigned a value of zero. There were no prior expectations as to who would be willing to

pay more, male or females. There were 337 respondents who indicated that they were female, 211 indicated that they were male and 62 did not respond.

Responses to question 18, age, were coded as six separate dummy variables, where a 1 indicated the presence of the age group, and a 0 its absence. This was to allow for the possibility that the various age categories had different effects on the willingness to pay. There were 7 between 15 and 24, 43 between 25 and 34, 134 between 35 and 44, 175 between 45 and 54, 135 between 55 and 64, 50 who were over 65 or older, and 40 did not respond.

Income categories (Question 19) were transformed into six dummy variables where a one represented presence of the income category and a zero denoted its abscence. It was expected that income would be a significant variable when estimating willingness to pay. This transformation permitted different effects among the income categories. It was expected that the higher the income group, the higher would be the willingness to pay. There were 29 who indicated less than $25,000, 127 between $25,000 and $49,000, 143 between $50,000 and $74,999, 77 between $75,000 and $99,999, 64 between $100,000 and $124,999, and 50 who indicated $125,000 or more. There were 120 respondents who did not respond to this question.

All of these coding changes resulted in a reduction in sample size from 610 to the 472 used for the final regression model.

Estimation and Final Regression Model

Estimation focused on finding the best overall fit (the greatest maximum likelihood). Often, when estimating an equation, it is of importance to determine marginal effects of each variable when all others are held constant. Because only one variable in the model is not binary (landscape expenditure), marginal effects are not presented. In addition, the marginal effect of any one variable is dependent upon the relative level of the other variables, and thus comparison is difficult.

The nature of the data presented many problems when estimating the maximum likelihood equation. One accepted method of estimating an equation is to place all available independent variables in the equation. There is at least one problem with this approach. Given the prevalence of dummy variables, multicollinearity is likely to be present. Consequently, a sequential approach was taken. Initially, regressions of the willingness to pay on each individual variable were estimated. Variables that had insignificant coefficients were not considered in subsequent estimations. Regressions of combinations of significant independent variables from the simple regressions were estimated. Equations were compared on the basis of their log-likelihood values, with the objective of finding the set of variables that generated the largest log-likelihood value. Table 3 contains the set of variables used in the final regression. The equation that generated the highest log-likelihood is given in Table 4.

Table 3. Characteristics of Variables Used in Maximum Likelihood Estimation

Variable		Mean
Willingness to Pay for Resistant Dogwood	Dollars	$13.35
Presence of Dogwood in Landscape	0 = No, 1= Yes	.74
Presence of Powdery Mildew in Dogwoods	0 = No, 1= Yes	.20
Sum of Landscape Expenditures	Dollars	$803.36
Presence of Annual Flower Bed	0 = No, 1= Yes	.57
Satisfied with Landscape	0 = No, 1= Yes	.41
Select Landscape Trees Based on Disease Resistance	0 = No, 1= Yes	.22
Select Landscape Trees Based on Fruit	0 = No, 1= Yes	.10
Shop for Landscape Plants, Shrubs and Trees from Farm Market/Truck Stand	0 = No, 1= Yes	.23
Knoxville, Tennessee	0 = No, 1= Yes	.24
Nashville, Tennessee	0 = No, 1= Yes	.44
Detroit, Michigan	0 = No, 1= Yes	.22
Income of $125,000 or More	0 = No, 1= Yes	.10

Table 4. The Estimated Regression Equation

Variable	Coefficient*	Standard Error
Constant	10.5909	1.4253
Presence of Dogwood in Landscape	-2.7932	.8927
Presence of Powdery Mildew in Dogwoods	2.2491	.9306
Sum of Landscape Expenditures	.0007	.0002
Presence of Annual Flower Bed	2.1098	.7330
Satisfied with Landscape	-2.7693	.7410
Select Landscape Trees Based on Disease Resistance	3.3267	.8655
Select Landscape Trees Based on Fruit	-2.7873	1.1247
Shop for Landscape Plants, Shrubs and Trees from Farm Market/Truck Stand	-2.1029	.8440
Knoxville, Tennessee	3.3260	1.4019
Nashville, Tennessee	2.4146	1.3001
Detroit, Michigan	3.9564	1.4513
Income of $125,000 or More	3.9564	1.2177

*All coefficients are statistically significant at the .05 level.

Log-Likelihood = -1521.753

Chi square = 75.524*

Sample Size = 472

As hypothesized, the presence of a dogwood in the landscape decreased the willingness to pay. The conclusion is that consumers who already own a dogwood tree were not likely to purchase another and were, therefore, unwilling to express a higher value for a disease resistant tree.

The dollar amount spent on landscaping, as expected, had a positive effect on the willingness to pay.

One item from Question 6 was found to be statistically significant, the presence of annual flower beds in the landscape. This could be interpreted as a reflection of the tastes and preferences of the respondents. Dogwoods are most noteworthy for their spring blooming season. Respondents who placed a high value on flower beds were likely to have appreciated a dogwood in full bloom, and thus, the positive coefficient.

The respondents who were content with their landscapes were willing to pay less for the resistant tree.

Among reasons a respondent selected landscape trees, two were statistically significant: disease resistance and fruit. Disease resistance, as expected, had a positive coefficient. People who were concerned about disease resistance were willing to pay more. Respondents who were interested in fruit trees were willing to pay less for the resistant tree.

It was expected that the type of outlet where respondents purchased landscape trees and plants affected willingness to pay. Those who shopped at outlets where the price of a dogwood was higher, or where the quality of plants was perceived to be higher, were expected to indicate a willingness to pay more for any landscape plant. Only one of the outlets was significant at the .05 level, farm market or truck stand, and its coefficient was negative. These outlets are

generally less expensive, and therefore, willingness to pay a premium for disease resistance was lower. The implication is that the demand curve for the resistant tree is not parallel to the demand curve for a non-resistant tree.

The city in which the survey was conducted had a significant affect on willingness to pay. Nashville, Knoxville, and Detroit all had positive effects on the willingness to pay versus Jackson respondents. The inference is that respondents in Jackson were less likely to pay more for the resistant tree.

One income category had a significant coefficient. If the respondent indicated a household income of more than $125,000 a year then he or she would be more likely to pay more for the resistant tree versus the other income categories. This variable, like farm market or truck stand, also indicates that the shift in the demand curve is not parallel.

Chapter 4: Marketing Implications

The results of the limited sample of home and garden show attendees suggest that, when compared to an identical dogwood tree, consumers were willing to pay on average $13.35 more for a dogwood tree that is resistant to powdery mildew. The willingness to pay response may overstate the actual premium that would be paid because: (1) no payment occurred, (2) the interest of respondents in landscapes, and (3) the presentation of information about the disease. It is also important to note that this premium was measured at the retail level and reflects a cumulative effect, so that each agent in the supply chain cannot expect to receive this premium.

Study results can be used to assist landscape growers, wholesalers, and retailers when marketing resistant dogwood trees. The goal should be to market the trees in a way that reflects the willingness to pay. Most of the individuals who attended one of the four home and garden shows were willing to pay more for a resistant tree. These individuals were older and in a higher income bracket than the population as a whole and, interested in their yards.

Marketing to individuals who already have a dogwood in their landscapes is not likely to provide much benefit because the presence of a dogwood in the landscape decreases willingness to pay. Therefore, this tree might best be targeted at new home buyers and individuals who plan on relandscaping an existing yard. However, individuals who have dogwoods in their landscapes that suffer from powdery mildew are willing to pay more for this tree.

The presence of a dogwood and the presence of a dogwood with powdery mildew affect the willingness to pay in different directions. It may seem, because the two coefficients for the two variables differ by $.55, that a respondent who indicates the presence of both of these

variables would be willing to pay less for the resistant tree. But such an inference cannot be drawn since marginal effects can not be compared because the latter depend on the levels of the independent variables.

Individuals who spent more on landscaping were willing to pay more for a resistant dogwood. Retailers could instruct employees to get to know their customers, and their spending patterns, and target these customers when marketing resistant dogwoods.

Based on the relationship between perennial flower beds and increased willingness to pay, retailers could place resistant dogwood displays near perennial flower displays.

Respondents who were not satisfied with their landscapes were willing to pay more for a resistant dogwood. This seems intuitive, because these individuals are more likely to be in the market for landscape trees in general. In addition, individuals who are dissatisfied with their landscapes might also spend more in the future to improve their yards.

Respondents who selected landscape trees based on disease resistance were willing to pay more for a resistant dogwood. An implication is that information about powdery mildew and the resistant tree should be provided at the point of sale. This display should consist of pictures and non-technical explinations, much like the display used for the survey.

Consumers who are in the market for fruit trees are willing to pay less for a resistant dogwood tree. This is consistent with the possibility of substituting another type of flowering tree. It suggests care must be taken in the pricing of the resistant tree so that it reflects consumers' valuation of powdery mildew.

Consumers are willing to pay a smaller premium when purchasing resistant dogwoods from farm markets and truck stands. Given the significance of this variable, an implication is

that the price increase at the retail level may differ by outlet. This does not necessarily mean that these retailers should avoid stocking resistant dogwoods. There are at least three reasons for the lower willingness to pay. First, these outlets may have a lower price level in general, and therefore, willingness to pay a premium for a resistant tree may be less. Second, this type of retail outlet may attract buyers who pay lower purchase prices but are willing to pay higher opportunity costs such as travel cost to the point-of-sale and tree maintenance. Third, consumers may feel there is more risk when buying from this type of retailer.

The premium that respondents were willing to pay varied by city. Respondents in Nashville, Knoxville, and Detroit indicated that they were willing to pay more for a resistant tree than those in Jackson. This could be the result of a lower price level in general and does not mean that retailers in Jackson, Mississippi should avoid resistant dogwood stock.

Individuals with incomes greater than $125,000 a year are willing to pay more for a resistant tree. Among survey respondents who answered the income question, over 10 percent fell into this category. Thus, among people who attend home and garden shows, this income group is an important segment of the target market. Retailers could focus on promoting the tree in high income areas.

In addition to the tools that can assist retailers in marketing resistant dogwood trees, there may be considerable savings in production costs. Nursery growers producing resistant dogwoods may be able to reduce the investment of both money in and time to spray the trees. This is very advantageous to small producers who may be able to invest in spraying but do not because of the labor cost involved (Windham).

Consumers of landscape products can benefit from the production of the resistant dogwood as well. Among the benefits are a decrease in landscape maintenance cost, a decrease in opportunity cost associated with time spent spraying, and additional utility from viewing healthy trees. In addition an extra degree of landscape flexibility is given to the consumer who purchases a resistant dogwood. Since powdery mildew does less damage to trees located in direct sunlight, (University of Tennessee Extension Service) a resistant tree may be placed almost anywhere in the landscape.

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Appendices

Appendix A: Questionnaire.

University of Tennessee Landscape Plant Survey

All responses are voluntary and will remain anonymous

After viewing the poster on display and reading the information, assume your favorite retailer is selling dogwood trees (*Cornus florida*) that are 5 feet tall, have a 1-inch trunk diameter, are sold in a 5-gallon container, which are the typical size produced for consumers at garden centers and mass merchandisers.

1. **How much more would you be willing to pay for an identically sized flowering dogwood that is resistant to powdery mildew?**

$0 | | | | $5 | | | | $10 | | | | $15 | | | | $20 | | | | $25 | | | | $30

2. Do you presently:
[ ] **own a home,** [ ] **rent a home or apartment,**
[ ] **plan to buy a home within 2 years?**

3. Do you currently have a dogwood in your landscape? [ ] **Yes,** [ ] **No**
If yes, are the majority of your dogwoods in
[ ] **SUN;** [ ] **PART SHADE;** [ ] **SHADE**

Do any of your dogwoods have (*check all that apply*):

____ powdery mildew
____ anthracnose (leaf spots)
____ dogwood borer injury
____ dogwood twig gall midge
____ trunk cracks/splits
____ drought injury (brown leaf edges)
____ don't know

4. Approximately how much did you spend last year (1999) in your home garden and landscape on:

$_____ annuals & perennials;
$_____ shrubs;
$_____ trees;
$_____ seeds;
$_____ mulch;
$_____ spray service;
$_____ fertilizer;
$_____equipment;
$_____ mowing / maintenance;
$_____ pesticides;
$ _____ other _____

5. Describe your yard (*check all that apply*). Estimate its size in ____ **Acres or** ____ **Sq. Ft.**

[ ] **wooded lot,**
[ ] **perennial beds,**
[ ] **landscaped borders,**
[ ] **grass lawn,**
[ ] **mostly open yard,**
[ ] **vegetable or herb garden,**
[ ] **annual beds,**
[ ] **container plantings.**

6. Is your lawn and landscape maintained:
[ ] by **yourself or a family member**; [ ] by **hired help,** [ ] **left to grow on its own.**

7. **Are you content** with the appearance of your landscape? [ ] **Yes,** [ ] **No**

8. Do you regularly read a gardening/grower magazine? [ ] **Yes,** [ ] **No**
If yes, **which ones**? _____

9. Rank the **TOP 5 reasons** you pick landscape **TREES** (Rank Only 5; 1=most important).

_____ length of flowering period
_____ availability
_____ water needs
_____ longevity
_____ sun / shade preferences of tree
_____ resistance to insects / mites
_____ familiarity
_____ easy maintenance
_____ fruit
_____ growth rate
_____ attracts butterflies/beneficial insects
_____ native
_____ winter appearance
_____ flower color
_____ disease resistance
_____ size / shape
_____ soil preferences
_____ attracts birds / animals
_____ leaf color
_____ flowering season
_____ university tested
_____ to create shade
_____ other: _____

10. To reduce pesticide use, what level of injury to plants in your landscape would you accept?
[ ] **high,** [ ] **moderate,** [ ] **low,** [ ] **none**

11. Are you familiar with these terms or concepts?

Term or Concept	Never Heard It	Sounds Familiar	I Know a Little	I can explain
Pest Tolerance	[ ]	[ ]	[ ]	[ ]
Biological Control	[ ]	[ ]	[ ]	[ ]
Mycorrhizal Fungi	[ ]	[ ]	[ ]	[ ]
Insecticide Resistance	[ ]	[ ]	[ ]	[ ]
Integrated Pest Management (IPM)	[ ]	[ ]	[ ]	[ ]
Pest Scouting / Monitoring	[ ]	[ ]	[ ]	[ ]
Beneficial Insects	[ ]	[ ]	[ ]	[ ]
Urban Landscape	[ ]	[ ]	[ ]	[ ]
Land Stewardship	[ ]	[ ]	[ ]	[ ]
Organic Gardening	[ ]	[ ]	[ ]	[ ]
Pheromone Trapping	[ ]	[ ]	[ ]	[ ]

12. If you were choosing plants for your landscape, what would your **TOP 5 considerations** be? (Rank Only 5; 1 = most important)

_____ insect/mite resistance
_____ water requirements
_____ to try a new plant
_____ sun / shade requirements
_____ soil preferences
_____ season of bloom
_____ winter appearance
_____ plant quality
_____ longevity
_____ attracts butterflies / beneficial insects
_____ University tested
_____ familiarity
_____ size / shape
_____ leaf color
_____ availability
_____ native
_____ length of flowering period
_____ disease resistance
_____ easy maintenance
_____ attracts birds / animals
_____ other: _____

13. **Where do you shop** for landscape plants? (*Check all that apply*)

____ retail chain
____ landscaper / contractor
____ independent / specialty garden center
_____ mail order catalog
_____ farm market / truck stand
_____ grocery
_____ direct from nursery
____ other _____

14. In your opinion, is the quality of landscape plants you purchase:

[ ] **excellent,** [ ] **good,** [ ] **mediocre,** [ ] **poor,** [ ] **not sure**

15. Are you satisfied with the performance of these plants in the landscape?

[ ] **always,** [ ] **often,** [ ] **sometimes,** [ ] **never,** [ ] **not sure**

16. Name a Beneficial (or Environmentally Helpful . . .):
insect _____ **bird** _____
plant / flower _____

16. Are you [ ] **Male,** [ ] **Female**?

17. What is your approximate age?
[ ]15-24; [ ]25-34; [ ]35-44; [ ]45-54; [ ]55-64; [ ]65+

19. Estimate your Gross Household Income before taxes this past year:

[ ] less than $25,000	[ ] $25,000 - $49,999	[ ] $50,000 - $74,999
[ ] $75,000 - $99,999	[ ] $100,000 - $124,999	[ ] $125,000 or more

Appendix B: Derivation of the Maximum Likelihood Function.

For respondent i, the actual willingness to pay, w*, is a linear function of K independent variables, including an intercept, and a normally distributed error term, e.

The underlying regression is:

$w^* = X\beta + \varepsilon$

w^* is an n x 1 vector of actual WTP.

X is an n x K matrix of independent variables.

ε is an n x 1 vector of errors, and is distributed normally with mean 0 and variance - covariance matrix $\sigma_\varepsilon^2 I$

The observed WTP is w_i:

$$w_i = L \quad if \ w_i^* \le L,$$
$$w_i = U \quad if \ w_i^* \ge U, \text{ and}$$
$$w_i = w_i^* \quad if \ L \prec w_i^* \prec U.$$

L is the lower censoring value, and U is the upper censoring value. Since ε is distributed normally, w* is distributed normally.

The expected value of w* for a given set of values of X, X_i, can be expressed in terms of the three components of the distribution:

$$E(w_i^* | X_i) = L[\Pr(w_i = L)] + U[\Pr(w_i = U] + \Pr([L < w_i < U) E(w_i^* | L < w_i < U)$$

The expected value can be expressed in terms of standardized normal values and density functions:

ϕ_j^* = probability density function for w_j^*,
ϕ_j = standardized probability density function, $\phi[(j - X_i\beta)/\sigma]$,
Φ_j^* = probability density function for w_j^*, and
Φ_j = standardized probability density function, $\Phi[(j - X_i\beta)/\sigma]$.

$$E(w_i^*|X_i) =$$
$$L\Phi\left(\frac{L - X_i\beta}{\sigma}\right) + U\left[1 - \Phi\left(\frac{U - X_i\beta}{\sigma}\right)\right]$$
$$+\left[\Phi\left(\frac{U - X_i\beta}{\sigma}\right) - \Phi\left(\frac{L - X_i\beta}{\sigma}\right)\right]X_i\beta$$
$$+\sigma\left[\frac{L - X_i\beta}{\sigma} - \frac{U - X_i\beta}{\sigma}\right]$$
$$= X_i\beta + \sigma\frac{\phi_L - \phi_U}{\Phi_U - \Phi_L}$$

Maximum likelihood estimation finds estimates of β and σ that give the greatest probability of generating the observed sample.

Given that a sample is drawn independently, the probability distribution for a set of observations is a joint probability distribution L^H.

$$L^H = \Pr(w_1, w_2, \ldots, w_n|\beta,\sigma)$$
$$= \prod_{i=1}^{n} E(y_i^*|x_i), \textit{ where } n = \textit{ sample size}$$

The log likelihood is the sum:

$$\log L^H = \sum_{i=1}^{n} E(w_i^*|x_i)$$

Vita

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