

Multiple Benefits from Agriculture: A Survey of Public Values in Minnesota

This study was conducted on behalf of the
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by

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Section 0.

Executive Summary

The State of Minnesota is considering the development of policies that would provide financial incentives to farmers for agricultural practices that yield multiple benefits to the environment. These multiple benefits include soil conservation and promotion of healthy soil, protection of ground water and surface water, floodwater retention, provision of bird and wildlife habitat, and trapping of potential greenhouse gases. Agricultural practices that yield these environmental benefits translate into economic and social benefits as well. The estimation of these economic benefits is the objective of this study.

Many of the economic benefits of improved environmental quality are not reflected in market-based transactions. Therefore, no market mechanism exists for people to reveal their willingness to pay for these kinds of improvements in environmental quality. In this case, estimating the total economic value of improvements in environmental goods and services requires a method that utilizes non-price (non-market) data. A stated-preference estimation technique known as contingent valuation is employed.

Contingent valuation employs a survey that describes the prospective policy and its effects. The survey also indicates to the respondent how much adoption of the policy would cost their household in terms of higher taxes and higher prices for goods and services. Citizens' willingness to pay for the benefits of the policy are elicited from their responses on how they would vote in a referendum on this policy, given its effects and financial consequences. A statistical valuation function enables estimation of mean household willingness to pay.

For this study a mail survey was sent to a randomly selected sample of Minnesota

households. Screening of an initial sample of 1,000 to exclude businesses, deceased, non-residents, and those without a valid mailing address yielded 834 potential respondents. Three hundred ninety four booklets were completed and returned, yielding an effective response rate of 47.2 percent. Also personal interviews were conducted in the two watersheds that were studied intensively in the other components of this project. Sixty four personal interviews were conducted in the Wells Creek Watershed and sixty one were completed in the Chippewa River Watershed for a total of 125 additional responses from Minnesota citizens.

This study evaluated the benefits that respondents derived from two different levels of multiple benefits. This study devoted most of its attention to a “baseline” policy scenario yielding a 50% reduction in most environmental impacts from agriculture. This was the level described in the interviews and half of the mail surveys, with the other half of the mail surveys describing a 10% level of reductions in environmental impacts.

For the baseline policy scenario, the mail survey resulted in an estimated annual household willingness to pay of \$201. The personal interview results show a much higher willingness to pay of \$394, possibly indicating “yea-saying” behavior from the personal nature of the interview procedure. It is consistent with the literature that personal interviews lead to higher estimates than responses to mail surveys.

Using the more conservative mail-survey estimate, a state-wide willingness to pay can be computed by multiplying the per-household figure (\$201) by the number of households (1.8 million in 1999) to yield an annual state willingness to pay of \$362 million. Given a state population of 4.75 million (1999 estimate) this translates into a figure of approximately \$76.21 per person annually or \$0.21 per person per day.

Section I.

Introduction

The State of Minnesota is considering the development of policies that would provide financial incentives to farmers for agricultural practices that yield multiple benefits to the environment. These multiple benefits include soil conservation and promotion of healthy soil, protection of ground water and surface water, floodwater retention, provision of bird and wildlife habitat, and trapping of potential greenhouse gases. Agricultural practices that yield these environmental benefits translate into economic and social benefits as well. The estimation of these economic benefits is the objective of this study.

Ordinary goods and services that are traded in markets have prices that indicate their economic value. Ordinarily, market price data are relatively easy to obtain, thus facilitating efforts to estimate the economic benefits associated with marketable goods. Agricultural commodities would be an example. In contrast, the multiple (non-commodity) benefits of agriculture are not fully revealed in market transactions. In order to estimate the economic value of improved environmental quality, methods that infer economic value from non-price data must be used. This study employed a method that enables estimation of willingness to pay based on people directly stating their preferences. This is known as the contingent-valuation method. The contingent-valuation method is a survey technique designed to elicit the willingness of a household to pay for a policy that will produce benefits for that household. This is a non-market analogue to the observation of a market transaction in which a consumer reveals his or her willingness to pay the market price for a good.

This report provides results from a state-wide contingent-valuation study designed to elicit

the willingness of Minnesota households to pay for environmental effects resulting from various agricultural practices. Two modes of survey administration were utilized: mail and personal-interview. The mail survey was sent to a sample of 970 Minnesota households (834 potential respondents) and personal interviews were conducted with 125 households. On the basis of responses to this survey, a valuation function was statistically estimated. These estimates provide information on the economic value Minnesota households would receive from the increases in multiple benefits from agriculture projected to result from the described policy.

Outline of the Report

Section II of this report summarizes some of the scientific information on the environmental effects of various agricultural practices. Section III lays out the conceptual foundations for economic benefits of improved environmental quality. Section IV provides a brief overview of techniques employed in the estimation of the economic value of improved environmental quality. Sections V through VIII describe the contingent-valuation method in general, and how the survey instruments for this study were designed and administered. Sections IX and X contain results from the statistical analysis of the survey data. Estimates of willingness to pay are provided along with descriptions of the models used to derive these estimates. A set of appendices provides details and exhibits supplementing the report.

Section II.

The Context for Agricultural Policy for Multiple Benefits

This contingent valuation study is one component of a larger project titled “Multiple Benefits of Agriculture Project: An Environmental, Social, and Economic Analysis.” As the name implies, the project is multi-faceted including modeling of the bio-physical impacts of various land-use practices and farming systems. In order to provide a factual basis for the estimation of the economic value of agricultural practices that yield multiple benefits a comprehensive study of outputs leaving farms under various production scenarios has been undertaken in conjunction with this study.¹

The mail survey had an insert describing environmental impacts from agriculture. It had two versions of these descriptions: a “Base Case” at 50% improvement for most effects except floodwater retention and greenhouse gases, and a lower-improvement case projecting 10% improvement for most effects. The mail sample was split into two equal sub-samples with half receiving the base case description and the other half receiving the description of lower improvements. This range of percentages for improvements was considered to provide upper and lower bounds on effects that would be a useful context for policy analysis. Gaining an understanding of the value people attach to these environmental effects projected for each version was regarded as important information in assisting the State of Minnesota in developing sound policy.

¹ For a complete discussion see Westra (2001). Excerpts from the Executive Summary are found in Appendix A to this report.

This study devoted slightly more attention to economic-valuation of the policy scenario deemed to be the base case in that half of the mail surveys and all of the interviews pertained to this case. This base case describes the levels of effects projected to occur from an ambitious, but realistic, application of financial incentives to farmers. The other version of effects was evaluated for comparative purposes, to allow some interpolation of a benefits function between these two levels of effects, and to test the validity of the economic-valuation instrument, particularly the sensitivity of WTP to the scope of effects.

The information presented in the economic-valuation survey provides a comprehensive summary of the informational context for policy to reward farming practices that yield multiple benefits. The remainder of this section is a verbatim excerpt from the mail-survey instrument for valuation of the base case. It describes the environmental impacts, the proposed program and costs to households.

THE ENVIRONMENTAL IMPACTS OF FARMING PRACTICES

SOIL EROSION

Soil erosion occurs when soil particles are carried away by wind and water. The current rate of soil erosion from water and wind on Minnesota cropland varies across regions. The average ranges from 4 to 8 tons per acre per year (which is 2560 to 5120 tons annually per square mile.)

EFFECTS:

- *Reduced soil fertility:* Erosion removes important parts of the soil and can reduce its fertility.

PROPOSED SOLUTIONS:

- *Encourage the planting of grasses (including pastures), trees and shrubs.*
These make the soil less likely to erode from wind and water.
- *Encourage terracing and contour farming in hilly areas.*
These methods of planting crops reduce soil erosion from water.
- *Encourage conservation tillage.*
This method of farming minimizes tilling the soil and keeps the soil covered with crop residue. It helps to reduce wind and water erosion.

EXPECTED RESULT:

- Soil scientists expect the program to cut soil erosion in half. Extensive scientific research has established evidence on the effectiveness of various farming practices in reducing soil erosion and overall pollution leaving the farm.

WATER QUALITY

Farming methods have effects on water quality. Rain can wash fertilizer and pesticides into streams and lakes. Bacteria (and other microorganisms) from animal manure can run off into streams and lakes. Nitrogen from fertilizer can get into groundwater.

EFFECTS:

- *Health risks*
Runoff of nitrogen from fertilizer and manure causes health risks to humans, especially infants. Bacteria (and other microorganisms) from animal waste can cause digestive and other health problems in people of all ages. These can enter the body through drinking water or through the mouth while swimming.
- *Recreation*
Water quality is important for swimming, fishing and other recreation.
- *Fish populations*
Reduced water quality reduces the variety and populations of game-fish species.

PROPOSED SOLUTIONS:

- *Encourage the planting of grasses, trees and shrubs next to streams and lakes*
These plantings, known as “filter strips”, can be effective in trapping fertilizer, pesticides and eroded soil so that they do not get into streams and lakes.
- *Encourage the conservation and restoration of selected wetlands*
Almost half of Minnesota’s wetlands have been drained over the past 100 years, mainly to increase agricultural production. If wetlands are conserved and restored, they will help trap pollutants and eroded soil that reduce water quality in streams and lakes.

EXPECTED RESULT:

- The program is designed to reduce the amount of agricultural runoff to groundwater and surface water by 50%.

FLOODING

Some farming techniques have encouraged rapid draining of water from the land and into streams. These practices contribute to an increased risk of flooding.

EFFECTS:

- *Small-to-moderate flooding incidents*
These agricultural techniques that keep water from being retained on the soil increase the risk of small or medium sized floods (floods that occur on average every 2 to 10 years.) Extreme flood events (that occur on average every 50 to 100 years) would probably occur with any agricultural system.

PROPOSED SOLUTIONS:

- *Encourage the conservation and restoration of selected wetlands*
If wetlands are conserved and restored, they will help to retain water. This will reduce the risk of flooding.
- *Encourage farming practices which increase the amount of plant matter on or in the soil*
This increases the ability of the soil to absorb and retain water.

EXPECTED RESULT:

- The program is designed to reduce the amount of small to moderate sized flooding from agricultural land by one fourth. Scientists do not expect this to impact the most severe flood events.

BIRDS AND WILDLIFE

Land that is planted entirely in row crops does not provide good habitat for most birds and wildlife.

EFFECTS:

- *Reduced bird populations and bird variety*
More diverse landscapes, including grassland, wooded fence rows, wetlands, and a diverse mixture of crop plantings allow birds to nest and migrate more successfully. Scientists have found that species of both game and non-game birds can be 5 times as high on diverse landscapes, as compared to land in row crops.

A figure was included which was adapted from an article “Breeding Bird’s Habitat” in *The American Midland Naturalist* by L.B. Best, K.E. Freemark, J.L. Dinsmore and M. Camp, July 1995 Vol. 134, pages 1-29.

The figure illustrates 4 types of agricultural landscapes. Each square represents a plot of land that is ¼ of a square mile (160 acres). The four types of land uses shown vary in the application of these conservation practices. The degree of habitat diversity increases from left to right. The most diverse landscape (shown at far-right) supports up to 5 times more bird species than land planted entirely with row crops.

PROPOSED SOLUTIONS:

- *Encourage increases in the diversity of the landscape*
This would include wooded fence rows, grassy areas along waterways, conservation and restoration of selected wetlands. It would also include planting a diverse mixture of crops, instead of land that is entirely tilled for row crops.

EXPECTED RESULT:

- Scientists expect that the available bird and wildlife habitat on Minnesota farmland will increase by 50% as a result of the program.

GREENHOUSE GASES (CARBON DIOXIDE AND NITROUS OXIDE)

Agriculture can result in the release of greenhouse gases. Greenhouse gases contribute to the greenhouse effect, caused by the insulating effect of carbon dioxide, nitrous oxide and other gases that retain heat near the earth’s surface. Scientists refer to the idea that increases in these gases may cause changes in weather patterns and higher average temperatures as “climate change” and “global warming.”

Carbon dioxide: Conversion of land from native vegetation to cropland exposes carbon in the soil, and results in the release of carbon dioxide. The draining of wetlands for agricultural production also releases carbon dioxide.

Nitrous oxide: Nitrogen is a necessary nutrient for crops, and must be replenished in the soil through the use of organic or synthetic fertilizers. Nitrogen compounds in the soil can be chemically converted into nitrous oxide. Approximately 70% of the nitrous oxide released by human activity comes from agriculture.

EFFECTS:

- *Possible global climate change*
Climate change and global warming may have very unpredictable effects. It may result in more extreme weather events, or diminished productivity in some agricultural regions.

PROPOSED SOLUTIONS:

- *Encourage the conservation and restoration of selected wetlands*
If wetlands are conserved and restored, they will help to retain carbon dioxide.
- *Encourage conservation tillage*
This will help retain more carbon in the soil.
- *Reduce the use of nitrogen fertilizer on cropland.*
This will reduce the release of nitrous oxide.
- *Encourage the conversion of cropland into woodlands, grasslands, and pasture lands*
These uses of the land will help retain carbon in the soil and will reduce the release of nitrous oxide.

EXPECTED RESULT:

- The program is designed to reduce the release of greenhouse gases from agriculture by 10 to 20%.

DESCRIPTION OF THE PROPOSED PROGRAM

In this study, the program involves the effects of different farming methods on:

- the soil
- water for drinking, fishing, and swimming
- flooding
- habitat for birds and wildlife, and
- potential climate change.

Policymakers are considering programs that will provide financial incentives for farmers to use methods that increase the environmental benefits from agriculture.

Any farmer with land where it is possible to adopt certain conservation practices would be eligible. Participation by farmers would be strictly voluntary. The financial incentives to farmers could take the form of direct payments or tax reductions. The payments (or tax reductions) would increase for greater conservation results achieved, depending upon the

financial limitations of the program.

COSTS OF THE PROGRAM AND COSTS TO YOUR HOUSEHOLD

Currently estimates are being generated on how much this program would cost the typical Minnesota household. While economists can estimate the cost to the typical household, the costs to specific households will vary based on:

- the household's tax bracket and
- the household's spending pattern on some foods.

Funding the program could cause higher taxes or lower rebates.

If this program were implemented, the state would have to fund it by either spending less money on other programs (such as those mentioned at the start of this survey) or by increasing taxes or decreasing rebates.

Prices of some foods would increase.

This program would encourage conservation practices more than current policy and would likely result in a slight increase in the prices of some foods. Price increases would result from factors such as increases in the costs of production, lower production or the idling of some lands. The level of price increases would depend on differences in markets for various foods. Costs would be lower for households that purchase fewer of those foods that have the highest price increases.

The cost estimate has been calculated as a fixed annual payment over many years (at least a decade), similar to a fixed annual mortgage payment.

If this proposal passes, your household will have less money to spend on other things for at least the next ten years due to higher prices for some products, higher taxes or lower rebates.

Because costs will vary across households, we are asking different households about different costs within the expected range of costs. Please answer the questions carefully even if you view the cost stated in Q-13 as very high or very low. It is important that you tell us whether you would vote "For" or "Against" this proposal based on whether you view the environmental effects of the policy to be worth the stated cost to your household. Please consider how you would vote based on your current level of household income.

Section III.

Agricultural Practices to Provide Environmental and Economic Benefits

Discussion of Commodities and Public Goods from Agriculture

Development and implementation of policies that would provide financial incentives for providing multiple benefits can be conceptualized as producing economic goods. As described above, these multiple benefits include soil conservation and promotion of healthy soil, protection of ground water and surface water, floodwater retention, provision of bird and wildlife habitat, and trapping of potential greenhouse gases. Agricultural practices that yield these environmental benefits not only produce commodities but also provide collective non-commodity benefits that fit the economic definition of “public goods.”

Economic Goods Defined

The usefulness of economic analysis in the evaluation of policy options derives from the fact that policy changes produce costs and benefits. While the economic costs of adopting alternative agricultural practices may be understood by many people at a general level (e.g., short-term production may decrease or costs of production may rise, resulting in price increases), the economic benefits are often less apparent. This is due, in part, to the fact that improvements in the quantity or quality of environmental goods and services are typically not the kinds of economic goods that are exchanged based on market transactions. So preferences for these goods and services are not typically observable because people do not “vote with their dollars” in markets for these effects. Nonetheless, such improvements in environmental services are economic goods in a very real sense.

An economic good is something that produces improvement in human well-being. (In

economic-theoretic terms, this means that there will be positive demand at some price, with the lower limit on price of zero.) Economic goods provide value irrespective of whether the good is traded in a market. Therefore, policy changes resulting in improved or additional environmental services (e.g., greater opportunities for recreational activities, reduced risk to groundwater) can be viewed as “producing” economic goods, as long as some people receive value from such goods.

Categories of Economic Value

Economic goods vary in the degrees to which they are comprised of two principal components of value: “use value” and “passive-use value”. Use value accrues when someone gets satisfaction from some form of direct interaction with the resource. For example, people may engage in activities such as fishing or wildlife watching in Minnesota's lakes and rivers. Improvements in the quantity or quality of surface waters suitable for these activities will increase the quantity of goods that people value.

Value can also be generated due to preferences that are entirely separate from use of the resource in a conventional sense. Some people may derive increased satisfaction (well-being) simply from knowing that measures are being taken to ensure ecosystem health, whether or not they pursue “user” activities (such as fishing). These people derive economic value in a passive manner. A type of passive-use value that has received substantial attention in the literature is that of existence value.² There are several possible motives underlying existence value. These may include altruism, the desire to leave a bequest to future generations, or perhaps the capacity of people to derive satisfaction directly from the knowledge that ecosystems are being protected.

² This concept was first articulated by Krutilla (1967). See Mitchell and Carson (1989) for an overview.

Existence value has been identified in a variety of contexts, including for natural resources, places of historic significance, and great works of art.

Market vs. Non-market Provision of Goods

At this point in the conceptual discussion of value, a central question arises pertaining to the role of policy in providing these values. If environmental improvements are economic goods, does their provision need to be assisted by a public-policy process rather than being left up to market forces? If the answer to this question is “yes,” then development of sound policies would require information on the magnitude of value people attach to the additional production of environmental goods and services. If the answer is “no,” then perhaps the marketplace would do an adequate job of providing the proper level of environmental services. As is discussed below, the economic characteristics of many environmental goods and services support the conclusion that the answer is “yes.”

Some goods, typically known as “private” goods, have a characteristic referred to as rival consumption. Such goods tend to be compatible with provision by the private marketplace. The value of a unit of such a good accrues only to the person who consumes it. For example, consumption of a slice of pizza by one person precludes the consumption of that slice by anyone else. In the case of a private good, such as a slice of pizza, it makes economic sense to produce it if there is a person who places sufficient value on it to pay for the cost of production. Since each unit of a private good yields value only to the person consuming it, the value of the good is the value attached to it by that one consumer. In addition, the prices that people pay in the marketplace provide information about the magnitude of the economic value they attach to such goods.

As alluded to in the first paragraph of this section, other goods have a characteristic known as non-rival consumption--these goods are collectively consumed, and are conventionally known as “public” goods. One person’s accrual of benefits from reduced flood risks or lower greenhouse gas releases, for example, does not “use up” or preclude anyone else from receiving benefits from the same environmental improvement. Or they may be a mixture in the characteristics of “consumption” for effects such as improvements in fish and wildlife habitat. While there is some rivalry in the actual harvesting of fish, much of the economic benefit of a cleaner aquatic environment collectively benefits all users. In the case of passive-use value, consumption is non-rival in its purest form.

The public-goods character of many environmental resources results in distorted incentives in private markets, typically causing these goods to be under-provided. The absence of private markets for such goods means that people do not have the opportunity to make consumer expenditures so as to “vote with their dollars”. This implies that public intervention may be necessary to ensure provision of adequate levels of these goods. In addition, the lack of markets results in an absence of the price information that reveals economic value. An additional implication is that total benefit is not just the sum of private values across all units of the good. Rather each unit of the public good can provide benefits to many people simultaneously, so the aggregate value of each unit of the public good is the *sum* of values placed on it by the collection of all potential benefactors. This is because the non-rivalry of the consumption allows each unit of the good to be enjoyed by all people who have preferences for it.

Section IV.

Methods for Inferring Economic Value

Methods for estimating the willingness to pay (WTP) for environmental improvements fall into two classes: revealed-preference techniques and stated-preference techniques. Revealed-preference approaches involve examining peoples' behavior and using this information to draw conclusions about WTP. Stated-preference approaches involve the use of surveys to elicit information that can be used to estimate WTP. Important recent works on the conceptual underpinnings for measuring the economic value of environmental preferences are contained in Bateman and Willis (1999).

Referring to revealed-preference methods, Kopp, Krupnick and Toman claim, "The most developed probably are the hedonic-labor-market approach, the property-value approach, and the travel-cost approach to valuing recreation" (1997, p. 16). The hedonic-labor-market method is used for valuation studies on human health. It employs information on wage structures to see what "payments" (in the form of lower wages) workers are willing to make to have reduced job-related health risk. The property-value approach evaluates the contribution environmental quality makes to property values in the private-housing market. The travel-cost method uses information on the cost of travel to a recreation site as a proxy for the price people are willing to pay to use the site. This can reveal information on the strength of demand for the use-value of recreation services provided by increases in environmental goods. These are partial-valuation techniques in that they measure only some of the components of value that would accrue from improvements in environmental quality. In particular, they cannot measure some components of passive-use value, as such value is not associated with market behavior. A great deal of effort continues to be

devoted to these revealed-preference techniques. Many recent studies have applied the hedonic-property value approach to valuing environmental attributes. These include Leggett and Bockstael (2000), Mahan, Polarsky, and Adams (2000), Michael, Boyle, and Bouchard (2000), and Tyrvaainen and Miettinen (2000).

The principal stated-preference technique for environmental-policy analysis is the contingent valuation method (CVM). In recent years additional attention has been paid to conjoint analysis and contingent ranking and new applications are being developed for these stated-preference techniques. A noteworthy recent study by Earnhart (2001) combines revealed and stated preference methods in employing choice-based conjoint analysis. Other recent studies valuing multiple attributes are Gregory (2000) and Pendleton and Shonkwiler (2001). Alberini and Krupnick (2000) compare cost-of-illness and CVM estimates related to air quality.

CVM employs a survey method that characterizes the object of choice (e.g., the bundle of effects associated with a policy change). It is for the defined object of choice that CVM is designed to produce a monetized value. The object of choice must be framed within a credible choice context, and with clear financial consequences attached to the choice. A survey format in common use is to place the object of choice in a referendum-voting context. The respondent is asked whether they would vote yes or no on the policy, where adoption of the policy will have specific financial consequences to the respondent. These mechanisms must be credible (higher taxes, higher product prices, etc. as appropriate) in order for the stated choices to be meaningful. Under circumstances where the object of choice is properly framed and the credibility conditions are satisfied, the stated choices provided by respondents provide the basis for estimating WTP for the effects produced by the prospective policy change.

Section V.

An Overview of the Contingent-Valuation Method

The contingent-valuation method (CVM) is widely applied to the problem of estimating economic values of goods and services that are not traded in markets and for which no economic behavior is observable. These non-market characteristics are present when the “good” in question is in the form of an environmental amenity. As a result, contingent valuation is receiving increasing application for estimating the economic value of environmental goods. These applications include the estimation of economic damages from oil spills, the value associated with ecosystem preservation, the benefits of reduced pollution, the value of improved groundwater and surface water quality and wetland preservation. An important overview and compilation of case studies is contained in Bateman and Willis (1999).

The contingent valuation method utilizes survey methodology to reveal the monetary values placed on goods by respondents. The CV researcher must provide respondents with a realistic portrayal of the policy change, and describe the cost burden to their household. The cost burden is defined both in terms of its magnitude and the vehicle through which these costs will be paid (e.g., higher prices for products, higher taxes, etc.). A valuation question then typically follows, in which respondents reveal either directly or indirectly their willingness-to-pay (WTP) for the stated good. For example, a dichotomous-choice (or referendum) valuation question allows the respondents to reveal how they would vote in a referendum on the policy, given the policy's cost to their household. From such responses, the average WTP across households can be estimated. Alternatively, the valuation question can have an open-ended or payment-card format allowing the respondents to directly state their own dollar values. Brown, et al. (1996)

compared open-ended and dichotomous choice estimates for donations to a public good. They conclude that both formats lead to overestimates of willingness to donate and that it is more severe with the dichotomous choice format. See Mitchell and Carson, 1989, for an extensive discussion of these approaches.

The credibility accorded to the results of contingent-valuation studies is evidenced, in part, by the increasing support for its use as a method for estimating the economic benefits associated with policy proposals. For example, it is included in the federal government's prescribed procedures for analysis (Water Resources Council, 1979, 1989 and Department of the Interior, 1986). In addition, results from contingent-valuation studies were granted the status of rebuttable presumption in environmental-damage litigation cases by a U.S. Circuit Court of Appeals (*State of Ohio vs. the United States Department of Interior*, 880 F.2d 432, D.C. Circuit, 1989). These policy developments provide for the use of CVM as an estimation technique to establish compensable environmental damages under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA). The same now holds true for the Oil Pollution Act of 1990. Along with this increasing use has come increasing scrutiny.

In recent years, economists, psychologists and other survey researchers have vigorously debated the validity of using the contingent valuation method to estimate the economic value of goods that are not traded in markets. An evaluation of CVM was conducted by a high-profile panel appointed by the National Oceanic and Atmospheric Administration (NOAA). This panel assessed the usefulness of the method and recommended research protocols to improve the tool's performance. The conclusions reached by the panel were used by NOAA in its rulemaking under the Oil Pollution Act of 1990. The panel consisted of five distinguished researchers, and was co-

chaired by two Nobel laureates in Economics, Kenneth Arrow and Robert Solow. One of its members describes the task given to the panel as addressing the following question: "Is the contingent valuation method capable of providing estimates of lost nonuse or existence values that are reliable enough to be used in natural resource damage assessments?" (Portney, 1994, p. 8). According to Boyle and Bergstrom (1999) the effect of the NOAA findings has been to change the presumption that CV results are "innocent until proven guilty to now being presumed guilty until proven innocent."

Summaries of many of the issues can be found in surveys of the literature produced by Cummings, Brookshire, and Schulze (1986) and Mitchell and Carson (1989). The recent volume edited by Bateman and Willis (1999) covers many conceptual and methodological topics as well as institutional and empirical applications. Carson, et al. (1994) have assembled a bibliography on CVM that contains 1,672 references. The studies referenced include applications of CVM as well as diagnostic research designed to assess its validity and reliability.

Much of the research on CVM has focused on the extent to which it is subject to random error (imprecision) or systematic error (biased results). The most serious concerns have related to the possibility of bias (systematic over- or underestimation). The categories of bias, and how surveys are designed to mitigate bias, are fully discussed below in Section VI. A short, general summary of concerns about bias and the effect of survey delivery modes is provided in Ethier, et al. (2000).

Among the most interesting methodological studies are those designed to compare CV results to the values generated in simulated markets in which actual (as opposed to hypothetical) monetary transactions are made. Some of the most revealing work in this area is that by Bishop

and Heberlein on the exchange of hunting permits (Bishop and Heberlein, 1979, 1990 and Bishop, et al., 1983). Contingent values on willingness to pay were statistically quite close to those revealed in actual cash transactions. Contingent values generated from a sealed-bid auction were 33% higher than cash-transactions values. When the CV questions were in the dichotomous choice format (in which the respondent must agree or refuse to pay a specified price for the good), the CV results for willingness to pay exceeded the values from the simulated market by 13%. In neither case were the differences statistically significant.

Concern about how a good's characteristics affect the reliability of CV estimates is addressed in research by Kealy, Montgomery, and Dovidio (1990). Their research examined contingent values of two goods "...at polar extremes of the private/public good continuum: a brand-name candy bar and a contribution to a program to alleviate acid rain damage in a major recreational area (Kealy, et al., 1990, p. 259)." They hypothesized "...that contingent values for our public good would be less reliable and less accurate predictors of actual willingness to pay than those for our private good because the private good was more well defined and concrete, and because of respondents' greater familiarity with the private good (p. 259)." Their results, however, contradict this hypothesis. They found comparable reliability and predictive validity for both types of goods.

Much concern has been expressed regarding "embedding" bias in CVM results, a phenomenon which results in respondents exhibiting "insensitivity to scope". Insensitivity to scope would have been exhibited if, for example, respondent revealed the same willingness to pay for a policy which would reduce emissions of a pollutant by 10% as for a policy which would reduce emissions by 90%. The NOAA panel recommended that CV studies should be conducted

in a manner in which respondents sensitivity (or insensitivity) to scope could be tested. This would be used as one criterion by which the validity of the CV results could be judged.

Additional evidence regarding sensitivity to scope is discussed in Hanemann (1994). Some of the evidence reviewed by Hanemann is evidence contained in the meta-analysis by Walsh, Johnson and McKean (1992) on over 100 CVM recreation studies and in a study by Smith and Osborne (1994) on 10 applications of CVM to air quality. Hanemann discusses at some length the evidence provided in a review by Carson (1994) of 27 papers testing for sensitivity to scope, and notes that only two failed to generate statistical evidence of sensitivity to scope, the one by Kahneman and Knetsch (1992) and the other by Boyle, et al. (1994). That is, only 2 of 27 papers found evidence of this type of embedding behavior. Hanemann notes that critiques of these two studies have pointed to methodological shortcomings which could explain their findings. In summarizing the evidence Hanemann claims, "At any rate, even if one regards these two studies as highly credible evidence that respondents were insensitive to scope, they certainly do not represent the majority finding in the contingent valuation literature regarding the variation of willingness-to-pay with scope" (Hanemann, 1994, p. 35). Among these findings on sensitivity to scope are results by Smith (1996) showing significant differences in willingness to pay between public goods.

Regarding estimation of passive-use values *per se*, the NOAA Panel's conclusions are the most comprehensive and authoritative statement to date. Given that the NOAA panel was considering the use of CVM for environmental damage litigation (in which a single party could be held liable for environmental damages) they were compelled to adopt very strict standards by which to judge the method. After obtaining input critical of CVM, the panel noted, "... some

antagonists of the CV approach go so far as to suggest that there can be no useful information content to CV results. The Panel is unpersuaded by these extreme arguments" (Arrow, et al., 1993, 4610). After thorough review of the validity CVM for measuring passive-use values, the preponderance of evidence supports the usefulness of results from carefully performed CV studies. The NOAA panel concludes, "... the Panel concludes that CV studies can produce estimates reliable enough to be the starting point of a judicial process of damage assessment, including lost passive-use values" (Arrow, et al., 1993, 4610).

Section VI.

Survey Design

The Role of Focus Groups and Pretesting

Assessing General Context Through Focus Groups

A major purpose of focus groups in CV research is in survey design. Focus groups not only provide evidence of how the survey population views the policy trade-off to be studied, but also provides an intensive setting in which to understand how people will process the information and structure of the survey instrument. Two focus groups were conducted as part of the survey design. They were held in August and September of 2000: one in Watson for residents of the Chippewa River Watershed and one in Frontenac for people in the Wells Creek Watershed. A third group of Twin-Cities metro-area participants was recruited at random. These people were utilized for individual pretesting (with debriefing) of either the interview protocol or the self-administered the mail survey. The two focus groups conducted for this study began by assessing group participants background knowledge of agricultural and environmental issues in general. Participants' discussion of their familiarity with these issues and relevant policies revealed some level of knowledge about the topic, as well as some challenges in describing the policy context and payment vehicle for this study. After the initial discussion, participants were read drafts of sections describing the proposal and its expected environmental impacts and consequences for household budgets.

How Information is Understood and Interpreted

Further discussion was stimulated by asking participants to comment on the clarity and credibility of these descriptions of various effects of agricultural practices. This approach

afforded the opportunity to observe how the participants' interpretations of the information affected their definition of the benefits, prior to asking them to write down their vote and other information relevant to valuation. The discussion revealed that the importance attached to the effects varied among participants and was influenced both by different preferences and by the credibility people attached to the described environmental effects, where the greatest variation in credibility pertained to the greenhouse effect.

Participants were prone to touch on the economic consequences of these agricultural practices and their environmental effects. In general, the discussion indicated a strong tendency of people to see the connections between financial incentives, land-use practices and multiple benefits. They understood economic dimensions of the problem and consequences for their household budgets. While costs were expected for typical Minnesota households, participants identified the potential for net revenue for farmers participating in the program. People typically saw statewide implementation of the policy idea as the appropriate level as perhaps a first step in a process for revising federal farm policy. These incentives were viewed by a number of participants as being at cross currents, at least initially with the broader framework of federal farm policy focusing on commodities. Statewide implementation was deemed most politically achievable. Nationwide application of this policy idea met with greater skepticism and less confidence in program effectiveness. Also this reduced clarity in definition of the scope of the goods provided. Respondents identified the aspects of the descriptions that conveyed the information most clearly and explained how it influenced their thinking.

Assessing Effectiveness of CV Questions

The focus group setting is extremely useful for understanding how respondents regard the

CV questions in the specific policy context. Discussions tend to be very informative about the payment vehicle, in this case higher taxes and prices for goods and services affected by farming practices. It is possible to anticipate payment vehicles that might elicit emotional reactions which confound the assessment of willingness to pay. Both focus groups indicated that higher taxes are credible as the major part of the payment vehicle in order to fund financial incentives to farmers, but that this would elicit protests from some respondents. However it was deemed to be a necessary aspect of any realistic description of funding this program so needed to be included in the description.

Simulating CV Responses

Having focus-group participants engage in the referendum-style CV process and discuss their reaction to it is not only useful in generating preliminary indications of values attached to the policy, but also in "getting into people's heads" on how the CV mechanism is understood. It also affords the opportunity to debrief respondents on the motives that underlie their values and their reasons for favoring or opposing the proposed policy.

Implementation of Pretesting

As noted above, two focus groups were conducted as part of the survey design. They were held in August and September of 2000 for residents of the Chippewa River Watershed and the Wells Creek Watershed. A third group of Twin-Cities metro-area participants were utilized for individual pretesting of the entire interview protocol and the mail survey.

In addition to the focus groups, the three types of pretests recommended by Dillman were also performed.³ Recommended pretests involve the following three groups: (1) professionals

³ See Dillman (1979) for an authoritative guide to survey design and administration.

experienced in survey design, (2) users of the information, and (3) members of the survey population. The professionals who critiqued the numerous versions of the survey instruments included economists familiar with agricultural and environmental policy, practitioners of CV and survey research, academics in related fields, and a reading specialist who evaluated the instrument for level of difficulty in vocabulary and reading. An unusual strength of the pretesting in this study was the close scrutiny of survey design provided by the Core Working Group involved in the overall guidance of the larger study encompassing the CV work.

The second pretest group provided substantial feedback on numerous versions of the instruments. Many improvements were suggested by James Vincent, John Westra, Mara Krinke, George Boody and Mark Schultz. Improvements were made in the technical accuracy of the descriptions and in the clarity of information delivery.

Pretests were also conducted with members of the survey population. Early drafts of the instruments were assessed using interviews with citizens. As drafts became better-developed, people were recruited to self-administer the survey, followed by a debriefing session assessing the clarity of the instrument and the credibility of the described effects and payment mechanism. Responses to these pretests also produced information upon which the distribution of household costs for the full survey would be based.

Defining the Good to be Valued

The Contingent Valuation Method is termed as such because values are elicited based on described policy changes which would produce public goods. Benefits would accrue if the effects of the policy are regarded as economic goods. The survey design process becomes all the more crucial because it defines the elements of the policy that would generate these benefits. Hence

benefits estimates depend on these described policy impacts.

The policy consequences that people may value in this case are the multiple benefits of agriculture. All of these elements are described in the description of the policy. The effects are improvements in soil, groundwater quality, surface water quality, floodwater retention, bird and wildlife habitat, and the reductions in releases in greenhouse gases.⁴ Through pretesting and focus group discussions these effects were identified as economic goods to the extent that people value improved environmental quality, reduced risks to human health and property, and greater abundance and diversity of birds and wildlife.

The Environmental Effects of Agricultural Practices

Section II discusses the context for agricultural policy to encourage multiple benefits. The verbatim descriptions from the mail survey are provided in that section. Identical information is provided in the mail survey and personal interview survey instruments, although wording and visual materials were altered slightly to fit the delivery mechanism. Needless to say the design of these descriptions was a crucial step in overall survey design. The first step in that process was to identify the categories of effects based on evidence in the relevant literature and from the bio-physical modeling. Eventually specific figures to quantify percentage reductions in soil erosion, run-off to surface water, etc. were included based on estimates from the modeling and corroboration with experts. Ongoing pretesting with citizens was conducted at these various stages in designing the descriptions of environmental effects. Emphasis was placed on clear communication of these effects and understandable and credible quantification of the magnitudes

⁴ For further reference see Section II of this report and the survey instruments. The complete survey instruments are contained in Appendix B.

of these impacts.

Information About the Proposal

Section II also discusses the policy context in terms of aspects of the proposal. Again verbatim descriptions are contained above in Section II and the entire survey is provided in Appendix B. Highlights are the financial incentives to farmers, voluntary participation, direct payments or tax reductions commensurate with conservation results achieved, and costs to households through higher taxes and higher food prices. The description of costs is designed to put respondents in the proper frame of mind in recognizing the economic trade-offs inherent in spending money on such a program so less money would be available for other things.

Potential Biases and Survey-Design Features to Mitigate Bias

As noted above in the section on CVM, much concern has been expressed in the literature about potential biases in benefits estimates based on CV responses. Recently the major concern has been with embedding bias, which would be seen empirically as insensitivity to scope. The benefits estimate might not vary with the scope of the good being provided if (1) people are predominantly supporting the policy to enjoy a "warm glow" or (2) if respondents misappropriate larger benefits from more comprehensive policies than the one being evaluated. That is, benefits which are overestimated due to part-whole bias will be insensitive to changes in scope, as long as those changes in scope are still within the improperly large scope within which respondents are embedding the actual policy.

Other biases of major concern in the literature are: (a) strategic bias, systematic error due to incentives to strategically understate or overstate value; (b) hypothetical bias resulting from the hypothetical nature of the market; (c) information bias, error resulting from conveying incorrect

information; (d) yea-saying bias, due to social pressure to support these kinds of policy proposals; and (e) starting point bias, which results from the household's value being influenced by the initial cost stated in the survey. The latter is primarily a concern in the open-ended CV format, so is not an issue in the referendum format utilized here. While the studies that investigate these potential biases are too numerous to review here, Mitchell and Carson (1989), Cummings, et al., (1986) and the NOAA Panel (1993) survey this literature.

This literature contains guidelines for designing CV instruments to mitigate these potential biases. The NOAA Panel protocol is among the more comprehensive and highly regarded within the field, though it has not garnered consensus in all of its recommendations. A common thread in the discussion of design features to mitigate biases is to achieve incentive compatibility, so respondents are motivated and enabled to provide unbiased responses. The referendum format on willingness to pay is fundamental to an incentive compatible study design.

Another cornerstone of incentive compatibility is consequence realism, so respondents believe the study results will actually affect policy as stated, as well as their household budget. The former is often referred to as policy consequence realism. The cover letter and booklet cover accentuate a strength of this study in that it truly is related to a process of policy proposal and design. The questions pertaining to geographical location and eligibility to vote are potentially useful covariates for statistical analysis. They also help serve the purpose of fortifying the image of the official nature of the study so that respondents take their task seriously.

The other element of incentive compatibility pertains to the household's consequences if this policy is actually enacted. Incentive compatibility also depends on respondents accepting that a burden will come from their household budget. The literature promotes a context that

emphasizes the household's income constraint and the cost of the policy. Here again this study addressed these elements through the preliminary questions on commitment of money to various programs. These questions remind respondents of the public budget constraints and the availability of substitute programs, in case respondents would not be mindful of these realities. They are also reminded to respond based on their current level of household income.

Focus group discussions indicated that people sensed a high degree of realism in both policy consequences and household budget consequences. Section IX, "Empirical Results" provides further evidence generated from follow-up (debriefing) questions regarding the credibility of the payment mechanism and the magnitude of the payment.

Cost of This Program to "Households Like Yours"

In accordance with the NOAA protocol and the recommendations of Mitchell and Carson, the study established a payment vehicle that is realistic: higher taxes and higher food prices. This payment vehicle may have elicited protest responses, especially to higher taxes. Tests of the effects of these protest responses are summarized in Section IX. The costs to households were explained carefully according to suggestions offered in focus groups and pretesting. As noted above, the description of costs is designed to put respondents in the proper frame of mind in recognizing the economic trade-offs in allocating scarce resources to such a program.

Other Aspects of Survey Design

Other aspects of the survey design were included not only to convey the proper valuation context, but also to mitigate potential bias. Questions were designed according to the NOAA recommendations on assessing respondent's acceptance of the information. Follow-up questions pertain to the respondents' views on the degree of the effects, the effectiveness of programs in

general and this policy in particular, and acceptance that their households would have to pay higher taxes and higher prices. Households were also asked about their difficulty in paying the costs of the policy. Other questions establish a profile of recreational activities and demographics.

The Use of Two Different Survey-Delivery Mechanisms

This study is strengthened by the utilization of two methods for delivering the CV survey: personal interview and mail questionnaires. The NOAA Panel favors the interview delivery mechanism based on the recommendations of a majority of practitioners, though some continue to conduct mail surveys. This determination of the NOAA Panel was based more on the advice of experts than on hard empirical evidence on the relative advantages of any survey delivery mechanism.

Interviews allow researchers to monitor the attentiveness of respondents and to interact with them, especially in answering questions if the information is unclear. But interviews are much more expensive so the costs can be prohibitive for obtaining a sufficiently large sample. The presence of an interviewer may also encourage yea-saying bias to a greater degree than anonymous mail responses where material can be read and reflected upon at the respondent's own pace, much as in preparing to vote in a referendum.

Based on the researcher's prior experience with mail surveys and the need for adequate sample size, mail surveys were also utilized to corroborate the personal interview results and to investigate sensitivity to scope in a more cost-effective manner. The dual implementation methods allowed investigation of the methodological issue of whether interviews are necessary to generate useful results. If the two delivery modes yield similar results, mail surveys would be preferable due to lower expense. Another conclusion separate from cost advantages could be that

the mail delivery mode is preferable in that it more closely emulates an anonymous, secret-ballot referendum. Mail responses also yield more conservative estimates by avoiding yea-saying bias.

The Purpose of Using Two Different Scopes of the Mail-Survey Instrument

The conceptual rationale for including at least two levels of the policy, or two levels of the good, is that demand estimation is founded on identifying at least two points on the demand curve for the good. In this study, two different levels of the policy were tested over two sub-samples within the survey population. This type of split sample is referred to as intersample variation in the scope of the policy.

This leads to the methodological rationale for including two levels of the policy. But perhaps the most important reason for the two versions is the most basic, that this reflects the reality of a policy situation where various levels of these multiple benefits might be achieved. The funding for this type of program and the resulting participation rates of farmers will greatly influence the magnitude of multiple benefits realized in Minnesota.

Section VII.

Survey Execution: Mail

Sample Selection and Source

The sample selection procedure employed here was also attentive to the NOAA guidelines in that probability sampling was performed on the population that matches the group of citizens that would be most directly impacted by the policy. The random sample for the mail survey was drawn by a firm that provides representative lists for social research, Survey Sampling, Inc. (SSI). The results section on response rate provides details of screening that was done to identify potential respondents including utilization of national change of address (NCOA) services.

Mailing Technique: The Use of Multiple Follow-Ups and Their Timing

Four mail contacts were made with potential mail respondents. The first, third, and fourth mailings included a survey booklet, while the second mailing was just a reminder letter. The four mailings were sent on January 3, January 16, January 30, and February 20, 2001. Appendix C contains the cover letters from the mailings.

Section VIII.

Survey Execution: Personal Interview

Sample Selection and Source

As with the mail survey, sample selection was attentive to the NOAA guidelines. Probability sampling was performed using the most current population lists in the two selected watersheds. The community awareness efforts in the Wells Creek Watershed have resulted in a high profile recognition of the watershed project among residents and the maintenance of a thorough and up-to-date mailing list. This mailing list was an excellent population list from which to draw the sample. Assistance from the Chippewa River Watershed Project also resulted in a comprehensive, though less current, population list for the purposes of drawing the sample.

As is often the case with sampling procedures, the sampling unit was defined as a dwelling unit. Rather than taking a census of all structures in which people dwell in these counties, the addresses for all households residing in the watersheds were compiled. The lists of households in the two watersheds defined the dwelling units from which the interview samples were drawn.

Interviewer Training

All interviewers were trained carefully for delivering the instrument for this study. While some interviewers had prior experience as professional interviewers, the special requirements and content for this project still required interviewer training to provide familiarity with this study. For those interviewers without experience, more elaborate training sessions were conducted on the conceptual background and guidelines of effective interviewing. Numerous practice interviews were conducted with project staff as part of the training, as well as supervised and unsupervised pilot interviews with members of the study population.

Advance Letters and Interviewer Contact Procedure

As is typically the case, potential interview participants were sent advance letters describing the study (in the most general of terms) so they could anticipate the visit by the interviewer during a specified time frame, without providing the person the chance (or specific reasons) to refuse participation immediately. Sometimes interviews were completed on the initial visit or the resident specified a more convenient time for completing the interview. Oftentimes no one was home when the interviewer visited, so a letter was left to that effect. Appendix C contains the advance letters and other materials given to potential participants in the personal interviews.

Interview Delivery Procedure

The interview instrument is provided in Appendix B. The initial screening portion identifies the procedure for securing interview participation. Interviewers were trained to follow the interview protocol. The interview script and visual aids provided in Appendix B are self-explanatory of the interview procedure, including the post-interview assessment performed by the interviewer on distractions, attentiveness, etc.

Section IX.

Empirical Results: Mail

Response Rate

A total of 394 booklets were returned by Minnesota residents after being completed in whole or in part. An additional 11 booklets were received that were not completed (containing no or very few responses.) The 394 completed, resident booklets represent 40.6 percent of the original sample of 970. Of the original sample of 1000 drawn by a survey sampling firm, six were businesses, 10 were deceased and 14 had moved out of Minnesota. Of the 970 mailings, however, 136 were not deliverable due to a change of address for which a valid forwarding address could not be identified by the national change of address service that was utilized in this study. Correcting for these 136 booklets that were not deliverable to Minnesota respondents, there were 834 potential respondents. The 394 completed booklets thus represent a response rate of 47.2 percent of potential respondents. This is within the typical range of response rates for CV studies conducted in recent years. However it is also suggestive of the gradual decline in response rates that has occurred over the last decade or so. Through time there has been a decline in the willingness of the general population to participate in surveys that provide motivation based purely on a sense of civic duty, as was the appeal in this study. Some CV researchers are turning to financial incentives to encourage response but that was not deemed desirable or affordable in this study.

Demographic Profile of the Respondents

The respondents represent all income and educational levels, and reside in all parts of the state. Seventy-three of 87 Minnesota counties had at least one respondent return a completed

booklet. Those counties not represented in the responses are among the least populated and tended to have only one or two potential respondents in the sample that was drawn. The following table shows summary statistics on income and educational levels for the respondents and for the state population as a whole. While exactly comparable statistics on income and education for 1999 are not readily available, statistics shown in Table IX-1 suggest that the sample has slightly higher educational attainment than the state population. Median household income for the population in 1998 (a year earlier) falls in the median category for the sample. The mean is lower in the sample because it is not skewed upward by high incomes due to truncation at \$100,000.

Comparing levels of educational attainment is also complicated by the fact that the survey respondent was asked to report their own level of education, not the average for the adults in the household. To the extent that a majority of the surveys are filled out by heads-of-households with educational levels that are higher than the average for other adults within the household, this would bias the sample statistics upward compared to the actual education levels of the households in the sample. Furthermore, as discussed below, the sample under represents households in the 18-34 age class, which could have an interactive effect on the level of education in the sample.

It is conventional practice in studies of this type to adjust economic estimates when sample demographics are found to differ from those of the state population, if those demographic variables have a significant impact on mean willingness to pay. Specifically, a weighted mean is

Table IX-1

*Income and Education Levels:
Mail Respondents vs. State Population*

	Respondents	State Population
mean household income*	\$ 48,600	\$ 61,813
median household income	\$ 45,000 – \$49,999	\$ 47,926 (for 1998, US Census)
<i>household income:</i>	(1999)	(projected 1999 from 1990 Census)
Less than \$25,000	21.6%	25.5%
\$25,000 to \$49,999	34.1%	26.0%
\$50,000 to \$74,999	22.3%	20.4%
\$75,000 to \$99,999	10.7%	12.9%
\$100,000 or more	11.5%	15.2%
<i>education by level:</i>		
no high school diploma	5.8 %	10.6 %
high school graduate or some college (includ. Assoc. deg.)	58.2 %	68.4 %
bachelor's degree or higher	36.0 %	31.0 %

** Note: Mean household income for the state is calculated using 1999 data on per-capita earnings and average household size, as reported by the State Demographer's Office. Direct comparison between mean incomes for the sample and population is not possible because the highest income category in the survey was above \$100,000. Incomes above this would increase the mean substantially to come closer to the population mean. Recalculating the population mean by truncating the highest incomes at \$100,000 requires more complete figures on the distribution of income, and the most recent figures are from the 1990 U.S. Census. Median figures are comparable despite truncation at \$100,000. Education levels are for 1997 population as reported in the Digest of Education Statistics.*

reported to adjust the sample mean to what would be expected in a sample representative of population demographics. In this case, the estimates reported later in this section indicate that education is not a significant influence on willingness to pay estimates, so no adjustment is warranted. While income is statistically significant in positively influencing willingness to pay, available demographic comparisons are similar enough to imply that recalculation of economic estimates is not necessary. It seems reasonable to conclude that the sample under represents households in the lowest and highest income categories, with a disproportionately high representation of those in the \$25,000 to \$49,999 range. Truncating the income categories at \$100,000 and above results in a lower mean household income for the sample than the population, so calculating mean WTP based on mean income for the sample should generate a lower-bound estimate of willingness to pay. This is consistent with the approach of this study to include factors and assumptions that introduce downward bias on WTP estimates to counteract the tendency (documented in the literature) for CVM results to overstate mean WTP.

Table IX-2 below compares the geographic distribution of the respondents to that of the population as a whole. The sample broadly represents the regions of the state, with a slight over representation of Greater Minnesota as a whole with lower than proportional responses from the seven-county Metro area. Indications are that no adjustments of economic estimates are necessitated by these demographics.

Comparison of mean household size suggests that the sample (mean household size of 2.53) closely represents the state population (2.52). The percentage of households in the sample with individuals under 18 years of age is 35.7% compared to 34.8% of households in the population. Median age of sample respondents is 49 years while the 2000 Census reports that the

median age of Minnesota adults (18 or older) is 44. Comparing the age distribution shows that age groups 18 to 34 are under represented in the sample with a more than proportional response

Table IX-2

*Geographic Distribution:
Mail Respondents vs. State Population*

	Respondents	State Population
TC Metro Counties	45.9 %	53.7 %
Non-TC, South/Central	31.0 %	26.2%
Northern	23.1 %	20.1%

Notes: The metro county category refers to the seven-county Minneapolis-St. Paul metropolitan area, which includes Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, and Washington counties. The northern Minnesota category includes the following counties: Aitkin, Becker, Beltrami, Benton, Carlton, Cass, Chisago, Clay, Clearwater, Cook, Crow Wing, Douglas, Hubbard, Isanti, Itasca, Kanabec, Kittson, Koochiching, Lake, Lake of the Woods, Mahnomen, Marshall, Mille Lacs, Morrison, Norman, Otter Tail, Pennington, Pine, Polk, Red Lake, Roseau, St. Louis, Todd, Wadena, and Wilkin. All other counties are in the non-TC south central category.

from 45 to 54 year olds and those 65 and over. In terms of reported race of respondents, 95% identified their race as white compared to 91% in the population.

The most dramatic difference between sample and population demographics is for gender: with males and females fairly evenly split in the state population but 70% of respondents being male. Further analysis shows that it is not due to misrepresentation of single versus multiple adult households, but rather that males overwhelmingly responded for two adult households. To the extent that these responses were consistent with survey instructions that answers were to reflect household views, this would not bias the results. Furthermore, gender was not consistently significant as an explanatory variable in regression results.

Regression Analysis

Choice of a Dependent Variable

As explained in Section VI, "Survey Design", the survey instrument contains two referendum questions: (1) a standard dichotomous choice question roughly midway through the booklet; and (2) a second, multi-category referendum question near the end of the instrument which allows the respondent to change their vote. For the regression results presented below, the first question is used to define the dependent variable. Frequencies of responses on how "definite" or "probable" the vote would be are provided in Appendix G.

Regression Results: Simple Specification

As noted above in Section VI, the mail instrument has two versions, corresponding to different percentage reductions in pollution leaving the farm (and corresponding differences in the bundles of environmental effects). The following results were obtained by estimating WTP using censored logistic regression on each separate sub-sample. In each case, the dependent variable (vote) is regressed on the household cost variable using logistic regression, and the parameters are then transformed into a censored logistic regression model for which the dependent variable is expected WTP. (Base case parameters: constant=-.604, slope coefficient on cost=.003; lower improvements: constant=-.25, slope coefficient on cost=.002. See Appendix D for details on the estimation procedure.)

These results show generally strong support for policies to provide financial incentives for farmers to increase multiple benefits from agriculture. The public's support is exhibited by

Table IX-3

Split-Sample Estimates of Willingness-to-Pay

Sub-sample	<u>Estimated WTP</u>	<u>n</u>
Base Case (50% Improvements for most effects)	\$201	188
Lower Improvement case (10% for most effects)	\$125	178

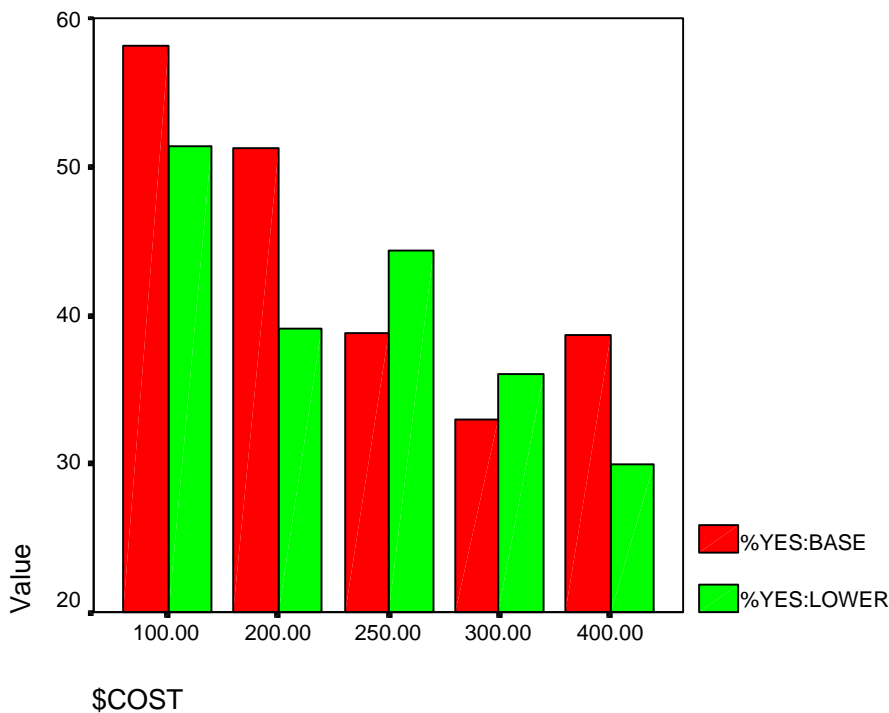
the substantial WTP⁵. Also it is an economically sensible result that the point estimates of WTP are higher for the base case than the lower-improvement case. Higher mean WTP for the stronger improvements is consistent with economic theory and these differences are statistically significant under certain functional forms (reported in detail below), providing statistical evidence of sensitivity to scope. This is an encouraging result given the rather small size of the two sub-samples and consequent large standard errors. The bar graphs below in Figure IX-1 show that the percentages favoring the policy vary according to costs to the household and between the two levels of improvements. The general patterns fit the theory that the percentage of YES votes should be higher at lower costs to households and for the higher levels of improvements associated with the Base case.

Regression Results: Alternative Specifications

⁵ While there is no theoretical justification for assuming that non-respondents (53% of the sample) have zero WTP, a curious reader may be interested in determining what the WTP would be under such a conservative assumption. Such estimates could be produced by multiplying the WTP figures in Table IX-3 by 0.47, the response rate.

There are numerous alternative approaches for deriving mean WTP. The means estimated in Table IX-3 are for all responses for the two sub-samples. An alternative to this approach of stratifying the sample into sub-samples is to use a single sample, but to include the two versions of effects (base case and lower improvements) as an independent variable. This is done below in Equations IX-1 and IX-2.

Figure IX-1: Percentage of YES votes by Level of Effects



In addition to adding variables to the regressions equation, another way to estimate WTP involves a different treatment of households who respond that they would be unwilling to support the policy at any price (even if there were no cost to their household). Such households do not perceive increases in the environmental benefits from agriculture as yielding any value to their households. In other words, for such households these environmental improvements are not seen

as an “economic good” so the probability that they would vote in favor of the policy is zero regardless of the cost to the household.

The overall sample thus consists of two groups: one group that regards these environmental changes as a “good” (so the probability of support varies with the cost to the household), and another group for which these effects are *not* a good (called the “NG” group.) Equation IX-1 is estimated only for the first group, since for the “NG” group there is no functional relationship between cost and support. Just under 30 percent of the respondent households fall into the “NG” category. These households may be added back to calculate an alternative mean WTP using WTP of zero per “NG” household. The mean WTP calculated from a simple logistic regression (only on costs) for the 258 sample households who regard the effects of the policy as a good is \$319. This number has limited usefulness because it combines WTP for the two levels of effects. Adding in the “NG” group at WTP = 0 reduces this average to \$225.

It is preferable to account for the two levels of effects in the regression. The logistic regression equation that accounts for the different effects levels (but excludes the “NG”s) is as follows:

Equation IX-1

Logistic Regression

*Estimation using Combined Sample,
“NG” Households Initially Excluded*

$$\ln[\text{Pi}/(1-\text{Pi})] = -1.075 + .005 \text{ COSTS} + .354 \text{ VERSION} - .031 \text{ EDUCATION} - .063 \text{ INCOME}$$

(1.082) (.001) (.275) (.068) (.027)

(standard errors in parentheses, Pi = probability of yes vote.)
(Yes vote coded = 0, No = 1 so variables that increase probability of yes vote have negative sign)

As noted above, VERSION is coded as base case = 1 and lower-improvement case = 2. EDUCATION is the years of school completed and INCOME is household income (measured in 5,000-dollar increments). In the above logistic regression, all of the slope coefficients have the expected sign in that the positive sign on “COSTS” and “VERSION” reflect that the NO vote (coded as 1) is more likely with higher cost and with the lower improvement version. Education and income both have the expected negative sign because increases in these variables should make the chance of a YES vote (coded as 0) more likely. A one-tailed test on VERSION is significant at the 10 percent level of significance. A one-tailed test on Education is not significant despite the correct sign of the slope coefficient even at the 10 percent level. Income and costs are both significant at the one percent level. Using the transformations discussed in Appendix D, the above equation yields the following censored logistic regression equation:

Equation IX-2

*Censored Logistic Regression
(derived from IX-1)*

*Estimation using Combined Sample,
“NG” Households Initially Excluded*

$$E(WTP_i) = 215 - 70.8 \text{ VERSION} + 6.2 \text{ EDUCATION} + 12.6 \text{ INCOME}$$

[means are: VERSION = 1.49, EDUCATION = 14.3 and

INCOME (in \$5,000 increments) = 10.7]

In contrast to the mean WTP of \$225, which is the average for the two levels of effects, Equation IX-2 yields more reliable estimates of mean WTP by separating the two levels of effects. For the base case (Version = 1) mean WTP for those respondents who view the policy results as

an economic good is \$368. When those who do not view it as an economic good are factored in, mean WTP is \$259. This regression equation implies that mean WTP for the lower-improvement case is \$297 which is reduced to \$209 when NG respondents are included.

Finally it is useful to estimate the logistic regression in Equation IX-1 using *all* respondents, including the “NG”s. This function can be converted to derive an expression similar to Equation IX-2. This equation can be evaluated for the two versions to generate additional estimates of mean WTP. These results are less reliable because they are based on responses from people who would vote NO regardless of the costs of the program. Including these responses reduces the statistical precision of all of the estimates, including the influence of other variables such as education and income. The implied WTP from this approach (evaluated using the sample means for income and education) is \$254 for the base case and \$192 for the lower-improvement case. Note that this approach yields similar results to Equation IX-2 but somewhat higher than the simple regression results on split samples shown in Table IX-3.

Other Adjustments to Mean WTP

A common practice in CV studies has been to adjust mean WTP by excluding responses that are identified as protests. Protest votes are defined as votes that do not reveal the respondent’s WTP, but rather are reactions to the context or the payment vehicle. Excluding protest votes is viewed as a way to refine estimates of WTP by narrowing the analysis to a core of legitimate responses that express preferences for the economic good. NO votes that are based on reasons that indicate objection to the context or the payment vehicle do not indicate the monetary value respondents attach to the effects. The rationale for this adjustment is similar to estimating the equation when NG responses are excluded, but the NG households are deemed as actually

attaching no value to the effects. Therefore after the equation is estimated excluding the NG responses, these households are added back in at $WTP = \$0$. In contrast, the conventional treatment of protest votes is based on the premise that these responses are not valid expressions of WTP.

The survey design allowed people to state their reasons to vote for or against the proposal. Frequencies on reasons for and against are provided in Appendix G. NO votes where respondents stated their opposition to increased taxes or said that funds should come out of the general fund or the lottery may be honest expressions of the respondent's view of the policy. However, as reactions to the payment vehicle, these responses disguise the household's WTP. It is not possible to determine whether or not the effects are viewed as beneficial, or as an economic good. Recall that just under 30% of respondents said they would oppose the policy regardless of cost. About a third of these stated reasons that are identified as protests. Therefore if these responses were discarded as protests rather than being factored in as $WTP = \$0$, the mean WTP estimate increases by about 10%.

Finally alternative estimates of mean WTP can be calculated using the follow-up questions to the vote that are designed to elicit statements of maximum WTP. As discussed above these follow-up questions allow determination of whether or not households view the effects as an economic good, but the open-ended WTP responses contain additional information. The responses to the referendum question are viewed as providing more reliable information. On particular the open-ended responses would be expected to suffer from starting point bias in that maximum WTP would be influenced heavily by the cost that was stated in the survey. However it is worth noting the average WTP calculated from these open-ended responses. Of those who

view the effects as an economic good, 30% said the stated cost was the most they'd be willing to pay. The mean for these respondents was \$228. Another third said they'd still vote for the policy at an even higher cost, with an average maximum WTP of \$543. The other 40% of the households that view the effects as an economic good, indicated their support by voting NO based on the stated cost, but said they'd vote YES at a lower cost. The mean maximum WTP for this group was \$265. Combining these open-ended responses on maximum WTP with the NG households added in at \$0 yields a mean WTP for the entire sample of \$186. It is a recurring result that open-ended responses yield lower values for mean WTP than estimates from the referendum-style responses. Still given this value is an average over both levels of effects, it corroborates the range of WTP estimates derived from the other approaches.

Other Significant Variables

The survey contains many questions that could be used as explanatory variables in the regression analysis. Some of these variables are highlighted in Appendix G. In addition to demographic variables, responses on activities, effectiveness, difficulty in paying, and ratings of issues could be used as explanatory variables. More elaborate versions of the regression model were estimated. However the estimation of WTP becomes more complicated as additional variables are added to the model. So Equations IX-1 and IX-2 report results on simpler functional forms that make estimation of WTP easier to follow. A variety of more complex versions of the regression model were estimated and it is noteworthy that a few additional variables were consistently found to be statistically significant. When a statistical result is obtained consistently under alternative assumptions or versions of the model, that result is said to be "robust."

With the variety of regression equations estimated here, the variable on respondents' ratings of likely effectiveness of the policy (Q-16) is consistent in its statistical significance. The subsequent question (Q-17) asked if the policy might be more effective than described. In most models, this variable was significant in that YES answers on more effectiveness tended to be associated with YES votes. Also the variable on difficulty in paying the costs is statistically significant in alternative models. However difficulty in paying was found to be closely associated with income, so the income was chosen as the better explanatory variable. None of the variables on activities or views on issues was consistently significant in alternative models, but supporting more spending to reduce water pollution (Q-6) and frequent hunting (Q-26) were significant in some models in tending to be associated with YES votes.

Credibility of the Payment Vehicle

In order for the contingent valuation method to provide valid results, respondents must believe that there will be some consequence to their household's budget if the policy is enacted. It is sometimes argued that respondents do not actually believe that they will have to pay should the policy be adopted. If many respondents did not take the budget consequences seriously than we should not observe that the stated cost would influence the likelihood of a YES vote nor should income influence their responses to the referendum. The results presented above show that both of these variables are significant, suggesting that the respondents are in fact conditioning their responses on these variables.

A more direct way to test for a tendency on the part of households to ignore the potential costs to their household is to ask the respondents if they believe that will have to pay the amount stated in the survey instrument. This was done in the mail instrument via question Q-21, which

asks “Do you believe your household would pay roughly the dollar amount shown in Q-13 in higher prices for products every year for the foreseeable future if this proposal passes?” The results to this question are shown in Table IX-4.

Table IX-4

Credibility of Payment Vehicle: Responses to Q-21

Question: “Do you believe your household would pay roughly the dollar amount shown in Q-13 in higher prices for products every year for the foreseeable future if this proposal passes?”

Yes	73.6 %
No	26.4 %

As the responses to this question shown, nearly three fourths of the sample believed in the stated dollar cost to their household.

Section X.

Empirical Results: Interviews

Demographic Profile of Interview Respondents

One of the reasons that conventional reasoning deems interviews as preferable to mail surveys is the greater success in achieving representativeness with mail surveys. In the case of CVM, some argue that the interview delivery mode is superior for conveying complex information to respondents. Response rates tend not to be treated with the same level of concern as with mail surveys. However it is not uncommon for both mail surveys and interview processes to elicit responses from about half of the households selected for a sample. In this study, interviews were completed with 64 of 94 people selected for the sample in Wells Creek and with 61 of 135 selected in the Chippewa River Watershed. The population list for Wells Creek was more current so there were fewer invalid names and addresses and there were fewer refusals among those who were contacted. As a success rate for completion among selected households, this would imply that the sample of interviews from Wells Creek would be of higher quality and more representative of the population in the watershed.

The watershed boundaries for both Wells Creek and the Chippewa River sub-watershed do not match county boundaries or township boundaries. County demographics are employed here as they match the watershed boundaries reasonably well and are more readily available and current than township information.

First it is useful to compare the demographics of the samples from the two watersheds to each other. Statistics on income, educational attainment, household size, presence of individuals under 18 years of age, gender, race and age are compared. Overall the statistics are quite similar,

being virtually identical for years of education and presence of children. Wells Creek responses report much higher income and slightly larger household size. Average age of respondents is also higher in Wells Creek. These differences are somewhat consistent with 2000 Census profiles in that Goodhue County has higher mean and median income, slightly larger household size. However Goodhue County has lower median age whereas the sample shows higher median age. Gender of respondents is skewed in Wells Creek toward males. While both counties are predominately white, 100 percent of Wells Creek respondents were white and 93 percent were white in the Chippewa sample compared to 97 percent in the county, meaning non-whites are slightly underrepresented in the Wells Creek sample and overrepresented in the Chippewa sample.

For further comparisons of population demographics to sample statistics, the samples from both watersheds underrepresent people in the 18 to 40 year old range and overrepresent people in their mid-sixties to late seventies. Despite exhaustive attempts to contact prospective interviewees at various times, with the greatest effort on weeknights and Saturdays, the sample is still influenced by the relative difficulty of interviewing people with day jobs and younger adults. Still the inclusion of households with children closely represents the population percentage in both counties. Again the ultimate concern about demographic representativeness is the need to adjust estimates of mean WTP according to population demographics. While the samples are close to population demographics in some respects, the variables where differences occur do not exhibit statistically significant influences on mean WTP, so no adjustments are reported here. Furthermore, the mail survey results are viewed as more indicative of the statewide population

and interview responses are deemed to be more susceptible to inflation due to yea-saying bias, so the more conservative estimates from mail responses are given greater attention.

Regression Analysis

Regression Results: Simple and Multivariate Specifications

The personal interviews elicited responses to a referendum-style vote on the policy. As explained in the previous section on mail responses (see derivations in Appendix F) logistic regressions can be estimated using the vote as the dependent variable and cost as an explanatory variable. This is informative in terms of the economic relationships and enables conversion into censored logistic regression which yields estimated WTP. Simple estimations on interview responses are reported here and comparisons are drawn to the mail survey results . These are presented below in Table X-1 for the first referendum question.

For the interviews, all respondents were presented with the base case of 50 percent improvement for most effects. The simple regression on all interviews regressing the VOTE on COSTS yields a constant of -1.574 and a slope coefficient on COSTS of .004. (For a discussion of the specification, see the discussion in the Section IX above entitled “*Regression Results: Simple Specification.*”)

Table X-1

Estimates from Personal Interviews

<u>Sample</u>	<u>Estimated WTP</u>	<u>n</u>
interview	\$394	124

In analyzing results from this simple specification as well as more complex model formulation, several patterns emerge. First, as with the mail survey results, the substantial WTP estimates from

the personal interviews are consistent with a strong level of support for the policy. The average household clearly perceives there to be a substantial benefit associated with these environmental effects. The estimates of WTP are substantially higher in the interview sample than the mail survey. This result is consistent with similar studies. (See Hagen, et al, 1998).

Second, some sensible results emerge from the statistical analysis of the interview data. Again cost influences the votes in the expected direction in that higher costs are associated with a lower probability of favoring the policy. The percentage of respondents favoring the policy generally declines as COST increases similar to the results shown in the bar graph on mail responses in Figure IX-1. Also income is significant in explaining the percentage of YES votes. The results in Equation X-1 are quite similar to the results for the mail sample in that COSTS and INCOME are significant but EDUCATION is not. VERSION is not a relevant variable for the interview sample because only the base case was described to respondents. These results are also consistent with economic theory and provide what is referred to as construct validity.

Equation X-1

Logistic Regression

*Estimation using Combined Sample,
"NG" Households Included*

$$\ln[\text{Pi}/(1-\text{Pi})] = 0.765 + 0.004 \text{ COSTS} + - 0.107 \text{ EDUCATION} - 0.135 \text{ INCOME}$$

(1.464) (.002) (.106) (.049)

(standard errors in parentheses, Pi = probability of yes vote.)
(Yes vote coded = 0, No = 1 so variables that increase probability of yes vote have negative sign)

Alternative Estimates of Mean WTP

It is worthwhile to consider alternative ways of estimating mean WTP. While greater emphasis on mail responses is warranted, certain alternative approaches deserve further attention. Various treatments of NG households (those who would vote NO regardless of costs) should be considered. It is not necessary to exclude protest NOs at this point, as it follows logically that discarding those NO votes would simply increase the estimate of mean WTP. When NGs are excluded initially (17% of the interviews compared to nearly 30% of mail responses) mean WTP increases to \$448. (The constant is 3.582 and the slope coefficient on COSTS is .008.) Factoring in the NGs at \$0 yields an alternative estimate of mean WTP of \$372. Running the regression on the sample with NG responses excluded improves the precision of the statistical estimates by restricting the data to core responses of people who are influenced by COSTS and other variables, rather than being opposed regardless of these factors.

One way to test whether mean WTP varies between the two watersheds is to include this as an explanatory variable in the regression. This is not significant at the 10% level suggesting that WTP is similar between the watersheds. When simple regressions are run separately on the two watersheds, mean WTP for Wells Creek is \$379 and \$416 for the Chippewa Watershed. Again while these figures may appear different in absolute terms, they are not statistically significant.

Estimating mean WTP from the open-ended responses on maximum WTP yields yet another figure for comparison. Of the 64% of respondents who voted YES on the first vote question, 42 said they would also vote YES at a higher cost. The mean value of maximum WTP for these households is \$409. Thirty one of those who voted YES said the stated cost was the

maximum, with a mean of \$278. Forty three of those who voted NO initially said they would vote YES at a lower cost, with a mean of \$152. Including NG households with these three groups yields a mean WTP of \$245. As with the mail responses this is consistent with the result in the literature that open-ended responses on maximum WTP yield lower estimates than the referendum format.

Considering all of these estimates of mean WTP in relation to comparable approaches with the mail responses, implies a tendency for the interview approach to result in higher values. Brown et al.(1996) reports similar findings. Lower estimates from the mail survey may reflect the “impersonal” nature of the mail survey. The presence of the interviewer may lead some respondents to react more favorably to the survey questions than if the survey were conducted in greater anonymity. Or it is plausible that higher WTP estimates from interviews indicate that the citizens of these two watersheds have higher mean WTP than Minnesota citizens as a whole. These areas have a higher dependence on farming and the Chippewa watershed is the more dependent of the two. In any case, there is no evidence from these results that the estimated WTP from the mail survey is biased upward vis-a-vis a personal interview approach (contrary to concerns expressed during the NOAA Panel proceedings). Given the conventional wisdom that CVM tends to overstate WTP, using mail responses and employing a method that yields lower mean WTP than other approaches seems appropriate in deriving a lower-bound estimate that is less prone to overstatement of the economic value of these public goods.

Other Significant Variables

Other variables emerged as significant influences on voting patterns in regressions on the entire sample as well as the data with HG households excluded. Income is consistently significant

at the 1% level. Contrary to the results from the mail sample, including the variable on difficulty paying does not cause INCOME to become less influential. As with mail responses, the less confidence people indicated in the effectiveness of the policy the less likely they were to vote YES. Additional corroboration of mail results is provided by the fact that engaging in hunting and the attaching a higher degree of credibility to the costs influence the vote, though not in all model specifications. Interview respondents rate the likely effectiveness of the policy even higher than the mail respondents. Again the credibility of the payment vehicle is quite high, with 64% answering YES about believing the stated costs, 24% stating NO, and 12% answering NOT SURE, which was not an option written into the mail survey. Overall these results are consistent with economic theory and provide further evidence of construct validity.

Section XI.

Summary and Conclusions

This study provides estimates of the willingness to pay of Minnesota households for a policy that would provide financial incentives to farmers for agricultural practices that yield multiple benefits to the environment. These multiple benefits include soil conservation and promotion of healthy soil, protection of ground water and surface water, floodwater retention, provision of bird and wildlife habitat, and trapping of potential greenhouse gases. Agricultural practices that yield these environmental benefits translate into economic and social benefits as well.

Many of the economic benefits of improved environmental quality are public goods and are not reflected in market-based transactions. Therefore, no market mechanism exists for people to reveal their willingness to pay for these kinds of improvements in environmental quality. In this case, estimating the total economic value of improvements in environmental goods and services requires a method that utilizes non-price (non-market) data. A stated-preference estimation technique known as contingent valuation is employed.

Contingent valuation employs a survey that describes the prospective policy and its effects. The survey also indicates to the respondent how much adoption of the policy would cost their household in terms of higher taxes and higher prices for goods and services. Citizens' willingness to pay for the benefits of the policy are elicited from their responses on how they would vote in a referendum on this policy, given its effects and financial consequences

For this study a mail survey was sent to a randomly selected sample of Minnesota households, with 394 completed booklets returned. This yields an effective response rate of 47.2

percent of 834 potential respondents. Also personal interviews were conducted in the two watersheds that were studied intensively in the other components of this project. Sixty four personal interviews were conducted in the Wells Creek Watershed and sixty one were completed in the Chippewa River Watershed for a total of 125 interview responses. Together these two samples capture preferences of over 500 Minnesota households, which represents a quality sample relative to the population and characteristics that approximate the adult population.

This study evaluated the benefits that respondents derived from two different levels of multiple benefits. This study devoted most of its attention to a “baseline” policy scenario yielding a 50% reduction in most environmental impacts from agriculture. This was the level described in the interviews and half of the mail surveys, with the other half of the mail surveys describing a 10% level of reductions in environmental impacts.

For the baseline policy scenario, the mail survey resulted in an estimated annual household willingness to pay of \$201. The personal interview results show a much higher willingness to pay of \$394, possibly indicating “yea-saying” behavior from the personal nature of the interview procedure.

Using the more conservative mail-survey estimate, a state-wide willingness to pay can be computed by multiplying the per-household figure (\$201) by the number of households (1.8 million in 1999) to yield an annual state willingness to pay of \$362 million. Given a state population of 4.75 million (1999 estimate) this translates into a figure of approximately \$76.21 per person annually or \$0.21 per person per day.

Section XII.

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Appendix A

“Foundations in Bio-Physical Modeling”, by John Westra.

(Attach in separate binder.) ???

Appendix B

Mail-survey instruments

Appendix C

Personal-interview-survey instrument, visual aids

Appendix D

Cover letters, follow-up letters and phone script for mail survey

Appendix E

Contact letters for personal-interview survey

Appendix F

Estimation Techniques: Logistic and Censored Logistic Regression

The conventional technique for estimating mean willingness-to-pay (WTP) from referendum data involves the estimation of a logistic regression equation of the following form:

$$\ln[P_i/(1-P_i)] = C_i + \beta'X_i,$$

where,

P_i = probability of an affirmative vote,

$\ln[P_i/(1-P_i)]$ = “log odds” of an affirmative vote,

C_i = cost to household i if the policy is adopted,

X_i = other explanatory variables (income, education, etc.) for household i ,

β = model parameters (to be estimated).

Solving for P_i yields:

$$P_i = [1 + \exp(-C_i - \beta'X_i)]^{-1},$$

which is the cumulative density function (c.d.f.) of the logistic p.d.f. From this expression the log-likelihood function can be derived and maximized with respect to C_i and β . The estimated mean WTP is obtained by integrating the fitted logistic c.d.f. with respect to C_i .

Censored logistic regression represents an extension of the above approach. Censored logistic regression has the advantage of providing an explicit expression for estimated mean WTP in the following form:

$$E(WTP_i) = \beta'X_i.$$

The β parameters can be obtained from the parameters of the conventional logistic regression model through the following transformation (Cameron, 1988):

$$= - \frac{1}{g_j} \cdot$$

Moreover, the asymptotic standard errors of the estimated β_j can be obtained from the variance-covariance matrix of the standard logistic regression model using the following transformation (Patterson and Duffield, 1991):

$$Var(\beta_j) = (g_j^2 / 4) Var(\beta_j) - 2(g_j / 3) Cov(\beta_j, g_j) + (1 / 2) Var(g_j) \quad (F5)$$

This yields estimates that are equivalent to those obtained by maximizing the censored logistic log-likelihood function. (Patterson and Duffield, 1991, demonstrate the mathematical equivalence of these two approaches, and provide an example. Hagen, Vincent and Welle, 1992, utilize both approaches and find that the results are identical.) All of the censored logistic regression estimates presented in this report were obtained by transforming the logistic regression parameters in the manner described above.

Appendix G

Frequency Tables of Responses to Selected Questions

Table G-1

<u>Program</u>	<u>Great Deal Less Money</u>	<u>Somewhat Less Money</u>	<u>Same Amount</u>	<u>Somewhat More Money</u>	<u>Great Deal More Money</u>
Making Highways Safer	1.5%	4.8%	51.1%	32.6%	9.8%
Reducing Water Pollution	0.8%	3.7%	32.3%	43.8%	19.4%
Providing Low-Income Housing	6.8%	18.7%	36.0%	26.1%	12.5%
Building New State Prisons	16.7%	27.2%	40.1%	12.3%	3.7%
Improving K-12 Education	3.4%	4.8%	26.1%	39.2%	26.4%
Assisting the Elderly	1.1%	3.4%	34.1%	43.1%	18.3%
Maintaining State Parks	2.3%	11.4%	55.8%	22.8%	7.7%
Reducing Air Pollution	1.1%	8.0%	37.6%	37.3%	16.0%

Table G-2

<u>Statement</u>	<u>Strongly Agree</u>	<u>Agree</u>	<u>Neutral</u>	<u>Disagree</u>	<u>Strongly Disagree</u>
More Family Farms	38.8%	34.2%	23.5%	2.0%	1.4%
More People on Land	33.2%	40.1%	23.1%	2.7%	0.9%
Farm-Related Businesses	44.0%	42.3%	12.9%	0.3%	0.6%
Health Care Plans	39.2%	37.2%	17.4%	3.8%	2.3%
Retirement Plans	27.2%	35.1%	27.5%	6.1%	4.1%
MN River	46.8%	42.2%	10.2%	0.9%	0.0%
MS River	47.1%	41.8%	10.5%	0.6%	0.0%
Native Condition	20.4%	30.3%	30.0%	14.7%	4.5%
Strong Relations: Neighbors	28.7%	44.0%	24.7%	1.4%	1.1%
Vibrant Rural Schools	31.2%	51.6%	14.6%	1.5%	1.2%
Vibrant Rural Churches	26.0%	43.0%	27.2%	2.0%	1.8%
Fewer Feedlots	23.5%	21.6%	43.5%	8.0%	3.4%
Better Managed Feedlots	35.1%	38.4%	23.5%	1.8%	1.2%
Increased Employment	30.2%	50.7%	16.4%	0.6%	2.1%
Average Farm Size Decrease	12.3%	16.4%	44.0%	19.2%	8.2%
Decreased Fossil Fuel Use	14.7%	28.0%	45.7%	8.7%	3.0%
Landowners in Community	28.8%	43.6%	23.4%	2.4%	1.8%
Reduced Barriers to Farming	36.5%	40.6%	18.7%	2.3%	1.8%

Table G-3

Community Size

Farm or Rural Area (Under 2,500 People)	23.1%
Small Town (2,500 to under 10,000 People)	21.4%
Small City (10,000 to under 50,000 People)	23.6%
Medium City (50,000 to under 100,000 People)	15.0%
Large City (100,000 People or More)	<u>16.9%</u>
	100%

Table G-4

Most Frequent Reasons For (10 or more responses)

Natural Environment Precious	34
Better Quality of Living: Water, Air, Wildlife	31
Protect Environment for Future Generations	30
Farm Prices Too Low, Help Farmers	11
Surface and Groundwater Quality	14
All Effects Described	23

(49 Categories Were Recorded from Q14A or Q15B as Reasons to vote Yes)

Most Frequent Main Reasons For (10 or more responses)

Natural Environment Precious	28
Better Quality of Living: Water, Air, Wildlife	18
Protect Environment for Future Generations	22
Air Quality	10
Birds and Wildlife	14
Surface and Groundwater Quality	23

(27 Categories Were Recorded from Q14A1 or Q15B1 as Main Reasons to vote Yes)

Table G-5

Most Frequent Main Reasons Against (5% or more of 55 responses)

Too Much State Control Already	5.5%
Oppose Paying Costs/Money, Can't Afford	20.0%
Don't Increase Taxes	32.7%
Already Subsidize Too Much Farm Production	5.5%
Take Out of General Tax Fund	5.5%
Close to Retirement, Fixed Income	10.9%

(37 Categories Were Recorded of Reasons to for Yes)

Table G-6

Effectiveness

Mostly Effective	20.3%
Somewhat Effective	60.2%
Not Very Effective	13.0%
Not Effective At All	<u>6.5%</u>
	100%

Table G-7

Difficulty Paying

Very Difficult	25.5%
Somewhat Difficult	30.5%
Not Too Difficult	24.4%
Not Difficult At All	16.8%
Not Sure	<u>2.8%</u>
	100%

Table G-8

Definiteness of Vote

Definitely For	23.0%
Probably For	19.9%
Not Sure	15.1%
Probably Against	17.6%
Definitely Against	<u>24.4%</u>
	100%

Appendix H

Verbatim Comments to Open-Ended Questions