Systematic Variation in Willingness to Pay for Agricultural Land Preservation and Implications for Benefit Transfer: A Meta-Analysis

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B.S., University of Connecticut

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Science

at the

University of Connecticut

May 2008

APPROVAL PAGE

Masters of Science Thesis

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2008

Acknowledgements

I would like to start by thanking my major advisor, Dr. Robert J. Johnston, for his guidance and support throughout the last two years of my graduate studies. Dr. Johnston provided me with many opportunities and challenges that have helped me grow as both a student and a researcher in the academic community. In the last two years, I attribute much of my progress to his tutelage and persistent patience that only a major advisor can provide.

I would also like to thank my co-advisors, Dr. Kathleen Segerson and Dr. Farhed Shah. I am grateful for Dr. Segerson's extensive knowledge and abilities as both a professor and academic advisor. Her encouragement and recommendations have been a blessing in the evolution of my career aspirations and interests. Dr. Shah has equally been a genuine source of enthusiasm and inspiration both in the classroom and as an advisor. His care for students and their personal growth as scholars is greatly admired.

The successful completion of my education is a direct result of the care and support I receive from close friends, colleagues, and family. I would like to especially acknowledge the endless love and support from my parents, Zbigniew and Barbara Kukielka; without whom none of my dreams could be possible. They were the first to introduce me to the world and all that is possible within it, and I attribute all my greatest motivations to their constant guidance and encouragement.

Additionally, I wish to thank my sister, Monica. My predecessor to college and the first to complete graduate studies in our family, she has always been the one to open my eyes to new opportunities and ideas.

Finally, and mostly, I would like to thank the person with whom I will share the rest of my life, Jakub Pusz. Together during each other's struggles in graduate school and beyond, he has seen me through some of the greatest challenges and achievements of my life. His love, patience, and dedication extend far beyond the requisites of friendship and devotion. A colleague, confidant, and fellow optimist throughout anything, I am truly blessed to have him in my life.

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Abstract

Over the past twenty years substantial research effort has been devoted to the assessment of farmland amenity values (Bergstrom and Ready 2005; Duke and Johnston 2007). A significant number of past assessments, for example, apply stated preference methods to quantify public willingness to pay (WTP) for farmland preservation. These studies investigate not only household values for preserving additional generic parcels of land (Halstead 1984), but also provide insight into voter priorities for attributes and amenities of preserved land (Bergstrom et al. 1985; Ready et al. 1997). Despite many case-study assessments of factors influencing WTP for the preservation of agricultural land, little is known about quantitative, systematic preference patterns that lead to WTP divergences across studies (Bergstrom and Ready 2003).

Meta-analysis has been drawing significant attention as a means to assess systematic variation in WTP, with applications to a broad range of resources and associated non-market values. However, to date, no published meta-analysis has been applied to farmland preservation values. This thesis describes the use of meta-analysis to examine systematic variations in welfare estimates derived from stated preference analyses of WTP for farmland preservation. The metadata are drawn from choice experiment analyses of WTP for farmland preservation conducted in North America. As the first statistical meta-analysis addressing WTP for farmland preservation, the paper examines both methodological issues related to the use of choice experiment results for benefit transfer, and empirical findings and policy implications. This thesis addresses the extent to which results justify the potential employment of MRMs for benefit transfer of farmland amenity values. This includes a detailed assessment of transfer error in various policy contexts and applications.

The metadata are drawn from eighteen choice experiment analyses of WTP for farmland preservation conducted in North America. Despite the small sample of studies, the capacity of choice experiments to forecast welfare estimates for a wide range of preservation options — characterized by differences in preservation attributes — results in numerous observations for WTP from each study. Hence, the relatively small number of studies generates metadata with suitable heterogeneity and sample size of 1582 observations. The meta-regression models are estimated following standard maximum likelihood estimation approaches with multi-level models used to address correlation among panel observations. Huber-White robust variance estimation is used to account for potential heteroscedasticity across observations. Estimates are generated for weighted and unweighted model specifications, and general results are extended to assess the impact of jurisdictional attributes on forecasted WTP values.

Results of the analysis are promising with regard to the ability of meta-analysis to synthesize information regarding WTP for farmland preservation and reveal systematic relationships unapparent from individual choice experiment studies. Initial meta-regression results indicate that various attributes are associated with systematic variations in WTP for farmland preservation, as reflected by variables in the metadata. These attributes are categorized into those characterizing: 1] study and methodology; 2] populations; 3] geographic region and scale; 4] preserved resources and services; 5] policy process; and 6] preservation context. Such findings are particularly relevant for benefit transfer—an issue of increasing relevance as more regions seek economic guidance for preservation efforts with few able to afford the cost of primary research. Given the generally unreliable performance of unadjusted benefit transfers, researchers are increasingly considering transfer methods that allow welfare measures to be adjusted for particular policy characteristics.

This thesis develops a broad benefit function for farmland values and its performance is evaluated across intrinsic jurisdictional characteristics. Evaluation of the validity of benefit transfer within this dataset, however, suggests that methodological attributes and jurisdictional size can significantly increase transfer errors. These findings imply that regional pooling – or pooling across different jurisdiction sizes – can degrade the validity of benefit transfers. As an attempt to mitigate poor transferability of WTP values, subsequent models evaluate state and community-level data separately. If split-sample models generate lower transfer errors, this may suggest that data groupings should be restricted to similar-size and scope sites.

Meta-analysis of the willingness to pay for farmland preservation appears to successfully identify systematic patterns across available studies. Initial assessments of underlying WTP measures suggest that estimated and predicted response values are close in value to the observed responses. Despite limited sample size, split-sample results do provide guidance on the role of jurisdictional attributes on benefit values. Comparative results from state and local data provide substantial support for community-level transfers, conditional on sufficient meta-data on significant resource and methodological attributes. However, larger jurisdictions and state-to-state transfers are subject to substantially higher errors, as all models indicate significant errors due to methodological heterogeneity. Attributes of valuation methods and survey sampling techniques generated the highest proportional contributions to transfer error results.

Comparisons across benefit transfer techniques also provide valuable insight to the performance of value prediction methods. The application of a cross-validation repeated sampling technique demonstrates substantial improvement in transferability, particularly for larger jurisdictions where transfer errors are substantial in other techniques. A review of transferability across these samples supplies information necessary to evaluate potential sources of bias within the data. Regressing transfer errors on explanatory variables from the metadata reveal systematic patterns of error contribution. These results also reveal areas on which researchers should focus to improve welfare value predictions and transfers.

Overall, model results are promising with regard to the ability of MRMs to identify components of systematic variation of WTP values and reveal patterns unapparent from stated preference models considered in isolation. Nevertheless, potential transfer errors may exceed acceptable limits. The results of this study indicate that meta-regression benefit function approaches can provide important information to guide potential policy programs across regions; however, results suggest cautionary uses of benefit function transfers of meta-regression results when considering direct benefit estimates in specific policy contexts.

I. Introduction and Purpose of Study

Over the past twenty years substantial research effort has been devoted to the assessment of farmland amenity values (Bergstrom and Ready 2005; Duke and Johnston 2007). A significant number of past assessments, for example, apply stated preference methods to quantify public willingness to pay (WTP) for farmland preservation. These studies investigate not only household values for preserving additional generic parcels of land (Halstead 1984), but also provide insight into voter priorities for attributes and amenities of preserved land (Bergstrom et al. 1985; Ready et al. 1997). Despite many case-study assessments of factors influencing WTP for the preservation of agricultural land, little is known about quantitative, systematic preference patterns that lead to WTP divergences across studies (Bergstrom and Ready 2003).

This thesis describes the use of meta-analysis to examine systematic variations in welfare estimates derived from stated preference analyses of WTP for farmland preservation. Meta-analysis is the systematic, statistical comparison of variations across multiple studies. These studies address related research topics, or specific resource contexts as in the case of this particular study. To date, no published meta-analysis has been applied to farmland preservation values. As the first statistical meta-analysis addressing WTP for farmland preservation, the thesis examines both methodological issues related to the use of choice experiment results for benefit transfer, and empirical findings and policy implications.

The metadata are drawn from choice experiment analyses of WTP for farmland preservation conducted in North America. Using these data, this thesis develops a broad benefit function for farmland values and its performance is evaluated across intrinsic jurisdictional characteristics. In addition, this study addresses the extent to which results justify the potential employment of meta-regression models for benefit transfer of farmland amenity values. Due to limited primary studies for individual towns and states seeking non-market valuations of their lands, benefit transfer is a method that can estimate economic values for natural resources by transferring available information from previous studies of comparable land policies. Investigations into the applicability of benefit transfers in farmland preservation are discussed, including a detailed assessment of transfer errors that results from the meta-regression model predictions.

Comparisons across benefit transfer techniques also provide valuable insight to the performance of value prediction methods. The benefit transfers performed in this study include direct data sampling techniques as well as simulated out-of-sample predictions to test the performance of common transfer techniques. The results of these benefit transfers are then reviewed to illuminate potential policy implications and guidance for future benefit transfer applications.

1. Organization of Topics

This thesis is organized into four primary sections. The first section provides a detailed literature review of the topics relevant to farmland preservation and non-market valuation techniques applied in historical studies. A brief overview of benefit transfer techniques, and the recent application of meta-analyses, is also discussed in the context of this study's purposes. The second section of this thesis defines the study methodology, including the sources and justifications of the compiled metadata and the specification of the empirical model. This section is concluded with a description of the theoretical expectations for the model results.

The third major section reviews the meta-regression model results and their implications relative to theoretical economic expectations. Within this section, our major benefit transfer techniques are defined and applied to the original empirical model results. A review of the performance of these transfers and their subsequent errors provides insight to the suitability of these data and regression methods to inform benefit function transfers for farmland preservation. Based on these findings, additional model specifications are reviewed for additional improvements or revealing information.

The final section of the thesis reviews overall findings from each model specification and their respective benefit transfer results. An overview of the study is provided with additional discussion of the possible factors that contribute to substantial transfer errors. Finally, recommendations for future work are summarized to guide subsequent analytical investigations.

II. Literature Review

1. Farmland and Open Space Preservation

For decades, the increasing rate of land development from residential and commercial growth has raised public awareness of land use decisions (Bergstrom and Ready 2003). In the short period between 1992 and 2000, over 8 million acres of farmland had been converted to developed uses. In response to this growth, public municipalities have pursued projects to aid in limiting development rates, including land preservation. Historic responses to these local and state bond referendums indicate substantial public support for farmland and open space preservation programs. In the state of Connecticut, for example, nearly 86% of the town land preservation bonds were passed in 2006 alone (American Farmland Trust 2007). In fact, every state currently provides some provision of tax incentives and other preferential programs to help encourage the viability of existing farmlands (Aiken 1989).

Farmland and open space preservation programs can be broadly categorized into those that prevent farmland conversion through zoning policies and reduced property tax rates, purchase or transfer of development rights though conservation easements (PDR and PACE programs), and “right-to-farm” laws (Rosenberger 1998). Although these are the most common preservation methods, other means of sustaining agricultural production may be possible. Regardless of the mode of action, the success of each of these programs depends on the available public or private funding.

1.1. The Role of Economics and Non-Market Valuation

Understanding the potential benefits and costs of community land use decisions can ensure that public policy decisions improve residents’ well-being, and that there is sufficient public support to implement associated policies. In 1977, Gardner proposed that productive agricultural land provides four main benefits: 1) local and national food security, 2) employment opportunities, 3) efficient uses and development of rural as well as urban lands, and 4) the provision of rural and environmental amenities (Lynch and Musser 2001). Many researchers dismiss the argument that farmland should be preserved to promote such market outcomes as farm employment and food production. In contrast, there is a general consensus that efficient provision of public or quasi-public amenity benefits from farmland requires public (government or non-profit) preservation activity, as these benefits will not be provided at an efficient level by unregulated markets.[1]

Farmland amenity benefits are external to traditional markets. Examples of the potential non-market amenities that farmland and open space can provide include rural community character, agrarian scenery, insulation from disamenities associated with developed land, and wildlife habitat (Johnston et al. 2001). Focus groups considering land preservation programs indicate that these benefits stem from environmental, anti-development, and use values associated with open spaces and farms (Kline and Wilchelns 1996). Market transactions, however, do not reflect the full value of farmland to the public because these amenity benefits are not bought and sold in markets.

Without insight regarding public non-market values for particular types of farmland and its uses, state agencies and non-profit land preservation groups may not allocate preservation funds in a way that best promotes public welfare. Since public and private preservation programs are supported through public taxes and individual donations, a

[1] The debate over the provision of food security and employment has mainly centered on a general argument of confidence in the market system's ability to allocate land between these uses. For more details of these debates, refer to Crossen (1982) and Gardner (1977).

mechanism for optimizing program prioritization can encourage the best utilization of these limited funds (Rosenberger 1998). Furthermore, the goals of these preservation programs may be inconsistent with general public preferences, as value estimate procedures may not be accurate (Kline and Wichelns 1996). Under-assessment of farmlands can lead to economic decisions that favor development or degradation of these resources. Without accounting for the additional benefits to society provided by land, the market may inadvertently lead to the purchase and development of a rural area (Bergstrom and Ready 2005).

There are a number of techniques that have been developed to estimate public willingness to pay for various farmland and open space preservation options (Lembeck et al. 1991; Bergstrom and Ready 2003). These studies investigate not only the household values for preserving additional generic parcels of land (Halstead 1984), but also provide insight into voter priorities for amenities that land can provide (Bergstrom et al. 1985; Ready et al. 1997; Irwin 2002). Once estimated, per acre per household estimates can be aggregated across a jurisdiction's population to provide estimates of total capitalized values for these lands (Ready et al. 1997; Bergstrom and Ready 2005). These estimated values may be utilized by policymakers to prioritize public policies by comparing total expected public benefits to the associated costs of different policies. Ultimately, the goal of these valuations is to guide the appropriation of funds that will reflect constituents' preferences (Johnston et al. 2001). However, limited original study site research raises an additional question of whether values from one particular study can accurately reflect the values of a different jurisdiction.

2. Benefit Transfer

2.1. Overview

Prior non-market valuation research provides valuable insight to the structure and magnitude of public preferences (Rosenberger and Stanley 2006). Results of any study, however, apply only to the jurisdiction and population over which the research was conducted. Knowledge of systematic variation in estimated farmland preservation values across studies and sites can provide a variety of insights into the potential use of applied welfare analysis for policy guidance. This insight can be particularly relevant for the use of benefit transfer to inform farmland preservation.

Benefit transfer may be described as the "practice of taking and adapting value estimates from past research … and using them … to assess the value of a similar, but separate, change in a different resource" (Smith, van Houtven and Pattanayak 2002, p. 134). More generally, it is a technique in which economic value estimates from previous studies are used to approximate values for a "policy site" in different, comparable locations (Desvousges et al. 1992; Loomis 1992; Rosenberger and Loomis 2003). Although the use of primary research to estimate values is generally preferred, the realities of the policy process often dictate that benefit transfer is the only option for assessing certain types of non-market values (Brouwer 2000; Rosenberger and Johnston 2007). The validity and accuracy of benefit transfers, however, depend on "the existence of a meta-valuation function from which values for specific issues can be inferred" (Rosenberger and Phipps 2007, p. 24). That is, valid transfer depends on systematic, robust patterns in the value surface across studies that allow WTP estimates to be transferred and adjusted based on differences between study and policy contexts (Bergstrom and De Civita 1999; Johnston et al. 2005).

Specifically in the context of agricultural preservation, the author is aware of only one quantitative benefit transfer assessments published in the literature (Johnston and Duke 2007). While this study provides important insight into the implications of several benefit transfer methods within a policy site, the results only address the performance of predicted values based on a single study site. As a result, this study presents a limited outlook on the potential of cross-regional benefit transfers for farmland preservation because it does not address the additional guidance that multi-study analysis can provide.

2.2. Types of Benefit Transfer

Benefits transfer methods can be divided into three major categories: 1) fixed value transfer, 2) expert judgment, and 3) value estimator or benefit function models (Bergstrom and DeCivita 1999).

Value transfer is the transfer of a single point or fixed value from an earlier study. The choice of value can be a single observation from within the study results, or a measure of central tendency (such as a mean observed value) across several observed value measures (Rosenberger and Loomis 2001). The single point method can be further broken down into two categories: 1) *unadjusted value transfer* and 2) *adjusted value transfer*. Unadjusted value transfer is the simplest method; assuming that the welfare change experienced by the average person in the study site is the same as the expected welfare change for the average person in the policy site (Colombo et al. 2005). This is a very strong assumption, especially considering the vast potential for differing utility functions across divergent populations. Nevertheless, under these assumptions, the general hypothesis is that the WTP values of the study site (WTP^s) are equal to the WTP estimates of the policy site (WTP^p):

$$WTP^s = WTP^p \tag{1}$$

The adjusted value transfer method includes additional explanatory information, such as socio-economic factors, to provide new predicted WTP measures. Here the general hypothesis is defined such that the predicted willingness to pay at the policy site is equal to the estimated WTP of the policy site, based on the study site observations that are adjusted to the policy context. Average value transfers are common in federal public land agencies when assessing land management and policy decisions (Rosenberger and Loomis 2001).

Expert judgment methods of obtaining transfer estimates aggregate values from a pool of expert citations or opinions. (Bergstrom and DeCivita 1999). Comparatively, value estimator or function transfer methods are derived from a sample of study-site observations, where a demand function is specified for the available data. This demand function can then be used to predict transfer values in a different policy site.

Benefit functions can be based upon random utility theory, wherein individual utility is divided into observable and random (unobservable) components (Hanemann 1984; Boxall et al. 1996; Hanley et al. 1998). These components consist of attributes that define both the policy and resource context, and include additional characteristics that economic theory predicts will influence public preferences. Function transfers can, therefore, be adapted to fit the characteristics of the policy site by including socio-economic characteristics such as income and housing distributions in addition to site-specific attributes. These demand functions, therefore, describe expected variations in public values based on resource and policy-specific attributes presented in valuation studies. Rosenberger and Loomis (2003) present a stylized equation to describe this function-based transfer:

$$W_i = f(X_i, \hat{\beta}i) \quad (2)$$

where W_i represents the sample observation from the study site. Here, X_i is a vector of attributes that can vary within the study samples, and $\hat{\beta}i$ is a vector of the estimated parameters determined by the study site results. More specifically, the function transfer assumes that the benefit function at policy site has the same parameters as the benefits function at study site:

$$\beta^s = \beta^p \quad (3)$$

where β^s is the vector coefficients at study site and β^p is the vector coefficients at the policy site (Colombo et al. 2005).

To reach this conclusion, benefit transfer methods assume that the original study site estimates are accurate and unbiased (Shrestha and Loomis 2001). If this condition holds, then the benefit transfer can be directly applied to the policy site, as the expected WTP value from the study site over the sample population would be approximately equal to the transferred benefit value of the policy site (Shrestha and Loomis 2001).

2.3. Meta-Analysis

Another approach to function-based benefit transfer is meta-regression analysis. Meta-regression analysis (MRA) is a method of statistical summarization of the relationship between welfare measures reported in studies and observable explanatory variables that contribute to the variation of these values (Rosenberger and Loomis 2001; Bergstrom and Taylor 2006). Comparing benefit estimates across sites in different locations is not considered in the other major methods of benefit transfer. Because previous methods only consider one study site at a time, evaluation of environmental value transferability across multiple regions or states is limited (Loomis et al. 1995).

Meta-analysis compares information from several related study sites and relates the magnitude value estimates to characteristics of the study resource (Rosenberger and Loomis 2000; Woodward and Wui 2001). This statistical analysis allows the researcher to control for varying methodological characteristics between sample studies and account for these differences when applying benefit transfer estimates to a potential policy site (Shrestha and Loomis 2003).[2] Like the demand function transfer approach, meta-analysis benefit transfers are sensitive to the underlying characteristics of the policy and study sites. The advantage of the meta analysis function over a demand function, however, is its ability to specify the expected impacts of different contextual and policy factors across the benefit value estimates before extrapolating this information onto the policy site (Rosenberger and Loomis 2000; Rosenberger and Loomis 2003).

Meta-analyses of existing non-market valuation studies—or more specifically meta-regression regression models (MRMs)—provide the primary means to assess the systematic patterns in WTP upon which function based benefit transfer depends (Johnston et al. 2005; Rosenberger and Phipps 2007). Recent works have given increasing attention to the potential use of MRMs to guide benefit transfer (Bergstrom and Taylor 2006; Johnston et al. 2005; Rosenberger and Stanley 2006). Table 1 lists some prominent examples of meta-analytical research in environmental economics.

[2] Many studies provide evidence that both resource and methodological characteristics have a systematic affect on welfare measure from stated preference surveys (Smith and Osborne 1996; Brouwer and Spaninks 1999; Bateman and Jones 2003; Johnston et al. 2003). Subsequent studies suggest that by controlling for methodological variations and other external factors, transfer errors are reduced (Johnston et al. 2003; Bergstrom and Taylor 2006).

TABLE 1. SAMPLE OF META-ANALYSIS STUDIES IN ENVIRONMENTAL ECONOMICS

Subject Area	Authors
Recreation	Bateman et. al. (2000); Markowski et. al (2001); Rosenberger and Loomis (2000); Shrestha and Loomis (2001); Walsh, Johnson, and McKean (1990)
Travel Cost	Smith and Karou (1990)
Urban Pollution	Smith (1989); Smith and Huang (1993, 1995); Van den Bergh et. al.(1997)
Wetlands	Brouwer et. al. (1999); Woodward and Wui (2001)
Groundwater Quality	Boyle, Poe, and Bergstrom (1994); Poe, Boyle, and Bergstrom (2001)
Air Quality	Desvousges, Johnson, and Banzaf (1998); Smith and Osborne (1996)

Source: (Bateman and Jones 2003)

From the perspective of applied transfer, MRMs can serve two potential roles. First, they may be used to identify systematic influences of study, context, and resource attributes on WTP, as a precursor to benefit transfer conducted using other means (cf. US EPA 2007). Alternatively, MRMs may be used to generate reduced form benefit functions for direct use within function based benefit transfer (e.g., Bergstrom and Taylor 2006; Moeltner et al. 2007; Johnston et al. 2005, 2006; Rosenberger and Johnston 2007; Shrestha et al. 2007; Rosenberger and Phipps 2007). There is widespread agreement on the suitability of MRMs for the former purpose, although there remain mixed opinions in the literature over the appropriateness of MRMs to estimate reduced form models for direct benefit estimation (cf. US EPA 2007; Rosenberger and Phipps 2007; Rosenberger and Johnston 2007).

Despite the increasing use of MRMs within the non-market valuation literature (e.g., Smith and Osborne 1996; Rosenberger and Loomis 2000a; Poe et al. 2001; Woodward and Wui 2001; Bateman and Jones 2003; Moeltner et al. 2007; Johnston et al. 2005, 2006; Rosenberger and Johnston 2007; Shrestha et al. 2007), there has been no published meta-analysis addressing systematic patterns in WTP for farmland preservation. This omission is reflective of a broader lack of analyses related to the potential for benefit transfer to inform farmland preservation or broader agricultural policy (Johnston and Duke 2007). For example, despite the qualitative insight available from Bergstrom and Ready (2005) and unpublished work of Ozdemir et al. (2004), the authors are aware of only one published, quantitative assessment of function based benefit transfer applied to farmland preservation (Johnston and Duke 2007). Hence, in regard to insight available from existing work, the potential for accurate, reliable transfer of farmland amenity or preservation values remains largely unknown.

As the foundation for subsequent discussion, we begin with a simple conceptual model for MRM statistical analysis and function-based benefit transfer based on MRM results. As noted above, MRMs summarize relationships between welfare measures reported in studies and observable explanatory variables that contribute to the variation of these values (Bergstrom and Taylor 2006). This statistical analysis allows the researcher to control for varying attributes between sample studies and account for these differences when applying benefit transfer estimates to a potential policy site (Shrestha et al. 2007). MRMs are generally structured with at least weak correspondence to theoretical assumptions, where variables of study attributes, resource and context characteristics, and socio-economic factors are specified with respect to their expected impact on welfare measures (Smith and Pattanayak 2002; Bergstrom and Taylor 2006). Given the meta-data obtained from available studies, one may specify the general functional relationship:

$$WTP_{ij} = f\ (\mathbf{X_{ij}, Z_{ij}, B_{ij}})\ ; \quad i = 1 \ldots N\ ; \quad j = 1 \ldots M \qquad (5)$$

where WTP_{ij} is the i^{th} observation from study *j*. The WTP observations are a function of X_{ij}, Z_{ij}, and B_{ij}, where X_{ij} and Z_{ij} are vectors of context characteristics for the resource and relevant policy measures, and methodological features of the study procedures, respectively (Johnston et al. 2006). As earlier meta-analyses have shown, both site characteristics and modeling methods have systematic influences on value estimates (Smith and Kaoru 1990).[3] In general, X_{ij} defines the characteristics of the transfer site within the policy context and is derived from the available study site information. Methodological characteristics, $Z_{ij,}$ are subjective in that the researcher must determine what qualities of methodology should be captured within the model in order to determine consistent instruments to capture these effects (Johnston et al. 2006). Finally, B_{Ij} stands for the estimated parameters from the meta-data sample.

Within the meta-analysis literature, equations such as that presented above are parameterized and estimated using standard econometric methods. When used for benefits transfer, the application of the parameterized equation for WTP calculation and subsequent benefit transfer requires that the analyst assign values (i.e., choose variable levels) for Xij and Zij. Together these estimated parameters allow WTP to be calculated for a given policy application and/or unstudied site. In contrast, value surface assessments (i.e., assessments of systematic patterns in WTP across observations) often involve assessments of only estimated parameters, B_{ij}, relative to theoretical

3 While there is no precedent for the optimal choice of functional form in performing meta-analysis, researchers must, nevertheless, remain aware of the potential implications of poor model structure Rosenberger, R. S. and J. B. Loomis (2001).

expectations or prior empirical findings. The following empirical analysis assesses the potential for MRMs estimated following specifications in equation (5) to contribute both to value surface assessments and to generate transferable benefit functions.

3. Sources for Transfer Estimates of Farmland Preservation Values

3.1. Valuation Methods

In farmland and open space preservation studies, three primary valuation techniques have been utilized: (1) Contingent Valuation (CVM), (2) the Hedonic Price Method (HPM), and (3) Contingent Choice (CC) and Choice Experiments (CE). Due to their wide application, each of these methods has been considered a reasonable approach to performing non-market valuation for state, local, and federal government studies (Bergstrom and Ready 2003; Freeman 2003). Hybrid methods are also common – such as combining both travel-cost and CVM valuations – in an attempt to capture both the use and non-use value estimates (Adamowicz et al. 1994).

Earlier farmland preservation studies applied standard HPM and CVM methods to elicit nonmarket values for farmland preservation. HPMs are a subcategory of revealed preference methods that are typically employed to investigate the impacts of farmland and open space on the overall real estate values of homes (Bergstrom and Ready 2003). Analysis begins by regressing property values on a number of observable household and location characteristics, including a variable for environmental quality or resource availability. These methods rely on the assumption that a consumer's overall purchases adequately reflect his welfare preferences (Smith 1993). The limitation of these methods is that they only reflect partial values; as these methods strictly account for direct use values. With these revealed preference methods there are no indicators of individual non-use values for a resource.

Contingent Valuation studies estimate individual Willingness-to-Pay (WTP) through a multi-alternative referendum approach under a stated preference survey. Earlier studies ask respondents to state their annual WTP for a parcel of land or policy by ranking several preservation options and fees. By their design, CVM studies focus on a particular issue or situation, obtaining information on respondents' preference for a specific scenario or program. However, by limiting the amount of descriptive information relevant to the policy decision in a referendum vote, there is a potential risk for misrepresentation of public preferences (Adamowicz et al. 1994; McFadden 1994). These characteristics of CVM also present some issues for generalization and benefit transfer goals in contemporary public policy making.

The applicability of meta-analysis to any particular research question is dependent on the quality and comparability of the available data (Johnston et al. 2005). Analysts must determine the optimal scope of the metadata (Rosenberger and Johnston 2007). The optimal scope may be interpreted as the exact definition of the dependent variable in the meta-regression model which, in turn, defines the set of source studies to be considered for inclusion. The tradeoff that ensues is often between maintaining homogeneity among dependent variables versus including additional information (i.e., observations) in the metadata.

Similarity, independent variable definition and study attributes within the metadata can be important for two reasons. First, theory may dictate that certain types of estimated values are not strictly comparable (e.g., Hicksian compensating surplus from a stated preference model versus Marshallian consumer surplus from a travel cost model).

Second, model fit may be improved by narrowing the metadata; for example, to include only valuation studies that use a particular valuation approach (Rosenberger and Johnston 2007).

Potential issues relevant to study selection criteria may be framed in terms of a requirement that studies included in metadata satisfy both *commodity consistency* and *welfare consistency* (Bergstrom and Taylor 2006). The former implies that "the [resource] being valued should be approximately the same within and across studies" (Bergstrom and Taylor 2006, p. 353). The latter implies that measures of public values based on these studies should be based upon the same measure of welfare. If they do not, then ex-post adjustments should be made to the calculations such that residual differences between theses estimates are appropriately accommodated (Bergstrom and Taylor 2006). Other considerations involve the tradeoff between the number of independent variables that may be included in a meta-regression analysis and the number of studies that are appropriate to include in the metadata, as each of these trade-off decisions play an incremental role in the robust design of the analysis (Moeltner et al. 2007).

Considering earlier valuation studies, these earlier methods have evolved. More recently, several farmland preservation studies focus on multi-attribute methods of choice-based models. Choice experiment modeling is believed to be the most accurate general purpose tool currently available for making probabilistic predictions about human decisions (McFadden 1994; Adamowicz et al. 1998; Johnston et al. 2001). Because of its advantages, choice experiment studies are also regarded as highly suitable methods for estimating consumers' willingness to pay in multi-dimensional situations (McFadden and Leonard 1993; Adamowicz et al. 1998). This thesis, therefore, exclusively considers valuation studies within the choice experiment framework.

3.2. Choice Experiments

Choice experiments are an alternative form of contingent valuation where a respondent must vote on the option that provides the most satisfaction or utility at a prescribed cost (Bergstrom and Ready 2003). Unlike contingent valuation—which typically estimates values for a single or very small number of policy or good configurations—choice experiments generate an empirical estimate of a utility function. This function allows analysts to estimate utility values for a wide range of policy or environmental good options and to assess how these values change when policy configurations are altered. The ability of choice experiments to adjust for differences in the attributes of environmental goods or policies within the study questions provides an increased capacity to accommodate differences between study and policy sites; thereby improving the potential accuracy of benefits transfer (Morrison et al. 2002; Morrison and Bergland 2006; Johnston 2007).

The choice experiment survey questions are designed to elicit responses that will allow the estimation of preferences over several environmental attributes (Adamowicz et al. 1998). In addition to choices for one policy over another, choice questions may also include an option to maintain the status quo and opt out from supporting any preservation option presented. Such provisions may aid in reducing biases stemming from a desire to "show you are in favor of the environment" or symbolic biases as described in earlier literature (Mitchell and Carson 1989; Blamey et al. 1999). Blamey et al. (1999) referred to this phenomenon as "yea-saying," where respondents vote in a symbolic fashion that may differ from their actual preferences and willingness to pay in a referendum setting.

From the observed responses, choice experiment studies assess potential relationships between public willingness to pay for farmland and open space preservation. The choice experiment survey framework includes multiple attributes that can influence public values. With the information provided by these attributes, the respondent must choose the option that provides the most satisfaction or utility at a prescribed cost (Adamowicz et al. 1998; Johnston et al. 2002; Johnston 2007). Among these attributes are characteristics of the land type, resource uses, geographic location, and amenities such as access that the land can provide. Inclusion of attributes is based upon underlying assumptions of characteristics that may affect people's preferences of willingness to pay for preservation programs. By varying the selected attributes within each choice question, the survey more rigorously elicits decisions from respondents based on his or her individual utility (Adamowicz et al. 1998). Furthermore, the provision of multiple survey versions with potentially hundreds of different choice questions allows for a detailed and systematic evaluation of the tradeoffs individuals make with respect to their personal preferences and overall willingness to pay for these preservation options.

Choice experiments result in utility function estimates based upon multi-attribute decisions scenarios; making these models highly suitable for benefit transfer (Bennett and Blamey 2001; Jiang et al. 2005; Johnston 2007). The multi-level, multi-attribute format of choice experiment questions is advantageous in its ability to assess changes in choices as a function of both changes in attributes and changes in the composition of competing alternative options (Louviere 1988; Adamowicz et al. 1994). Louviere (1988) presents statistically significant evidence that the choice experiment format is preferred over other valuation methods; arguing that the respondents face less burden of choice due to more realistic options. By presenting a variety of levels for several attributes, choice experiments also represent more realistic trade-off considerations for respondents (Louviere and Timmermans 1990).

These properties of choice experiments render the results of these models highly suitable for function based benefit transfer (Johnston 2007; Morrison et al. 2002; Morrison and Bergland 2006). Moreover, methodological homogeneity across contemporary choice experiments promotes valid pooling and comparison of study results within a meta-analytic framework, as it avoids complex influences of methodological heterogeneity that have confounded prior comparisons of farmland amenity values (Bergstrom and Ready 2005). For this reason, this study limits its focus to evaluation of choice experiment studies within the farmland preservation literature.

III. Study Methods

The ability to systematically compare studies of farmland values has been hindered by heterogeneity resulting from methodological differences. Methodological differences have been shown to contribute substantial variations in value estimates among the environmental resource valuation literature (Shrestha and Loomis 2003; Johnston et al. 2006; Rosenberger and Stanley 2006). In addition, the time difference of retrieving value estimates is a potential source of bias in cross-site benefit transferability (Bergstrom and Taylor 2006). Because the policy context within each study influences overall value estimates, socio-economic factors associated with economic eras may also impact welfare measures.

This study performs meta-regression analysis across choice experiment studies on farmland preservation. Numerous prior studies provide estimates of public WTP for farmland preservation in various policy contexts.[4] However, to date, no published meta-analysis has been applied to farmland preservation values. The use of a meta-regression model in this study is advantageous in its ability to assess the effects of key explanatory variables on the WTP outcomes. By rigorously controlling for attribute variations across sample study sites, this technique can produce estimates of WTP that are closer to the observed WTP values for the resource (Shrestha and Loomis 2001; Rosenberger and Loomis 2003). The meta-regression results attempt to reveal policy-relevant information on general public preferences and address implications for specific jurisdictional variations.

4 In CVM studies, historical ranges of values fall between $0.0002 per acre, reported in Bergstrom et al. (1985), to over $0.4392 per acre, as reported in Swallow (2002).

1. The Data

1.1. Studies, Selection and Criteria

The metadata for the present analysis are drawn from 18 choice experiment analyses of WTP for farmland preservation conducted in North America between 1996 and 2007. This pool of studies represents all multi-attribute choice experiments (known to the authors) that allow for the direct calculation of willingness to pay values per acre of farmland preserved, based on standard, utility-theoretic methods. These include all relevant choice experiments referenced in the review of Bergstrom and Ready (2005), in addition to additional grey literature and other studies published subsequent to this review. Additional studies were identified through: (1) review of published research and bibliographies dealing with WTP for farmland preservation; (2) review of recent issues of resource economics journals; (3) searches of online reference and abstract databases (e.g., Environmental Valuation Resource Inventory (EVRI)); and (4) personal communication with authors known to have published research assessing farmland preservation or amenity values. Overall, studies were drawn from peer-reviewed journal articles, theses/dissertations, and technical/government reports. Unpublished conference proceedings and presentations, however, were not included.

The selection criteria used to identify potential studies are based upon methods described in Rosenberger and Loomis (2001) and Bergstrom and Taylor (2006) reviews of meta-analysis procedures. Table 2 provides a brief overview of these criteria.

TABLE 2. SELECTION CRITERIA FOR METADATA STUDIES

Criteria	Detail/Reasoning
Conducted in the U.S. using accepted choice experiment methods	While limiting total sample size, this criterion maintains methodological consistency within the study and ensures that obtained WTP values reflect variations in other attributes of interest (land, socio-economic, and other methodological factors)
Choice questions directly addressing multi-attribute farmland preservation	The resource being valued must be consistent and comparable across studies for meta-analysis results to be valid. Also ensures that welfare estimates are consistent across each study
Study allows for or provides WTP/acre values	The estimated values must be in the same form in order to assess systematic variations due to explanatory variables.
Study provides sufficient information on resource attributes and methods of survey design/ analysis	Consistent information on the study design and methods eliminates the need to drop potentially significant explanatory variables; thus avoiding potential omitted variable biases in results.

Although the metadata include observations from all published choice experiment analysis of North American farmland preservation values, the number of such studies is limited. However, given the capacity of choice experiments to forecast welfare estimates for a wide range of preservation options—characterized by differences in multiple preservation attributes—each study in the metadata provides numerous observations of WTP. The availability of multiple observations per study is common for meta-analysis in the valuation literature (cf. Bateman and Jones 2003; Poe et al. 2001; Johnston et al. 2005, 2006b). Table 3 lists the final 18 studies selected for this analysis. From these studies, 1592 observations are drawn, averaging 88 observations per study.

TABLE 3. METADATA STUDIES AND SOURCES

Author (Year of Study)	No. of Obs. in Meta-analysis	Target Location of Study	Type of Publication (Citation Year)	Study Methodology	Mean WTP Values*	Range WTP Values*
Duke, J.M. and T.W. Ilvento (2001)	12	Kent County, DE	Published Paper (2002)	Tobit	0.00752	0.000402 to 0.04944
Duke, J.M. and T.W. Ilvento (2001)	12	Sussex County, DE	Published Paper (2002)	Tobit	0.00548	-0.00509 to 0.04475
Duke, J.M. and T.W. Ilvento (2001)	12	New Castle County, DE	Published Paper (2002)	Tobit	0.00843	0.00172 to 0.05156
Johnston, R.J., J.M. Duke, (2005)	180	State of Connecticut	Published Paper (2007)	Mixed/ Multinomial Logit	0.00231	-0.00742 to 0.01047
Johnston, R.J., J.M. Duke, (2005)	180	State of Delaware	Published Paper (2007)	Mixed/ Multinomial Logit	0.00269	-0.01388 to 0.01681
Johnston, R.J. J.M.Duke, T.W. Campson (2005)	180	Kent County, DE	Report/technical Paper (2007)	Mixed/ Multinomial Logit	0.16118	-0.31917 to 1.09351
Johnston, R.J. J.M.Duke, T.W. Campson (2005)	180	Sussex County, DE	Report/technical Paper (2007)	Mixed/ Multinomial Logit	0.24621	0.08889 to 1.08965
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Woodstock, CT	Report/technical Paper (2007)	Conditional Logit	0.13309	-0.67209 to 1.47731
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Brooklyn, CT	Report/technical Paper(2007)	Conditional Logit	0.15849	-0.33166 to 1.35352
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Pomfret, CT	Report/technical Paper (2007)	Conditional Logit	0.20122	-0.01968 to 1.03707
Johnston, R.J., J.M. Duke, J.B. Kukielka. (2007)	48	Town of Thompson, CT	Report/technical Paper (2007)	Conditional Logit	0.08567	-0.54722 to 1.00448
Johnston, R.J., J.M. Duke, T.W. Campson (2005)	180	Town of Preston, CT	Report/technical Paper (2007)	Conditional Logit	0.17253	-0.56964 to 1.41298
Johnston, R.J., J.M. Duke, T.W. Campson (2005)	180	Town of Mansfield, CT	Report/technical Paper (2007)	Conditional Logit	0.26512	-0.36533 to 1.47761
Johnston, R.J., J.M. Duke, T.W. Campson (2005)	180	State of Connecticut	Report/technical Paper (2007)	Conditional Logit	0.00537	-0.00811 to 0.01935
Ozdemir, S. (2002)	24	State of Georgia	Thesis (MS) (2003)	Conditional Logit	9.672E-05	-0.00032 to 0.00071
Ozdemir, S. (2002)	24	State of Ohio	Thesis (MS) (2003)	Conditional Logit	9.141E-05	-0.00036 to 0.00059
Ozdemir, S. (2002)	24	State of Maine	Thesis (MS) (2003)	Conditional Logit	0.00013	-0.000241 to 0.000863
Swallow, S. (1996)**	120	Town of Richmond, RI	Report/technical Paper (1995)	Conditional Logit	0.03351	-0.29707 to 0.53245
Volinskiy, D., J.C. Bergstrom (2002)	32	State of Georgia	Report/technical Paper (2004)	Mixed/ Multinomial Logit	3.639E-05	0 to 0.00062

* WTP Values reported as per acre per household per year
** Excluded from the sample studies due to inconsistencies in explanatory variables and study design. Study also excluded acreage values in choice questions, making it impossible to determine a WTP/acre estimate for the observations.

1.2. Explanatory Variables

The dependent variable for the meta-analysis is a monotonic function of WTP per acre, per household, per year for farmland preservation (see details below). In a small number of cases, estimates of WTP per acre for some or all observations are provided by study authors (e.g., Johnston, Duke and Kukielka 2007). However, in the majority of cases WTP per acre was calculated directly from parameter estimates and other data provided by the original studies, following standard approaches for choice experiments (e.g., Boxall et al. 1996).

Independent variables included in the meta-analysis are derived from a list of attributes with potential influence on WTP for farmland preservation, based on theory and prior findings in the empirical literature. These include variables characterizing farmland attributes, preservation context and methods, socioeconomic (population) variables, and methodological (study) attributes. For example, economic theory suggests that the WTP per acre for farmland preservation should increase as the incremental number of acres or the size of the parcel increases (Bergstrom et al. 1985; Rosenberger and Walsh 1997). Empirical evidence from the studies included in this sample demonstrate significant support for this assumption across several different resources (Ready et al. 1997; Rosenberger and Walsh 1997; Johnston et al. 2001; Duke et al. 2002; Ozdemir 2003; Ozdemir et al. 2004).

As emphasized by Johnston et al. (2005), meta-analysis almost universally requires reconciliation of variables and attribute levels across observations. Here, most reconciliations are straightforward, as alluded to in Table 2. However, as in most meta-analyses (e.g., Johnston et al. 2005), a small number of variables warrant additional interpretation.

For example, public access levels were grouped into three mutually exclusive categories – no access, moderate access, and high access. An observation was assumed to offer no access if the lack of public access was specifically noted in the survey scenario, or if public access was not mentioned as a possibility. The moderate access category included observations in which surveys specified either some form of passive recreational access (e.g., walking, hiking, etc.) or in which access was permitted in a restricted manner (e.g., only on a portion of preserved acres). The high access category, in contrast, included observations characterized by non-passive access (e.g., hunting or motorized access), or in which restrictions of accessibility remained unspecified.

Other variables that warrant explanation include those characterizing preserved land types. Original studies in the metadata address a substantial variety of land types; many of which are similar. For example, different types of crop or livestock farms are often grouped as food-crop land use (Volinskiy and Bergstrom 2002). To reduce the number of occasions in which a land type dummy variable distinguished only a single study, farmland types were assigned to aggregate groups. These assignments were based largely on the land cover, aesthetic and other properties of farmland. For example, the variable *forest* reflects land use that is characterized by forestry, orchard, or tree-farm productions. Other categorizations and final variable definitions are detailed in Table 4.

TABLE 4. DEPENDENT AND INDEPENDENT VARIABLES: DERIVATIONS AND ASSUMPTIONS

Variable	Description	Mean *(St. Dev)*
WTP**	WTP per acre, per household, per year. Calculated based on given coefficients in each study or reported MWTP values within study publications	0.289521 *(0.399603)*
IHS_WTP	A transformation of WTP values according to the inverse hyperbolic sine, such that the transformation equals: log(wtp + sqrt(wtp^2 +1))	0.108662 *(0.154255)*
No_obs**	Number of observations within each study. This value represents the total number of WTP estimates provided by the information in each study.	150.251 *(55.6187)*
No_obs_inv	Inverse of the number of WTP observations in each study. Provided as the weight in the weighted model specification.	0.010050 *(0.009230)*
IHSarea	A transformation of jurisdiction size according to the inverse hyperbolic sine, such that the transformation equals: log(area_ac + sqrt($area\_ac^2$ +1))	13.63609 *(4.54475)*
Acres_avg**	Average number of acres specified to survey participants; accounts for the average size of parcels upon which WTP values are based.	24108.57 *(156256.5)*
Acres_1to1K*	A binary variable indicating if the average acres presented in each study is 1000 acres or less. (1=acres_avg<1001, 0=acres_avg>1000)	0.623832 *0.484565)*
Acres_1to10K	A binary variable indicating if the average acres presented in each study is greater than 1000 acres but less than 10,000 acres. (1=1000<acres_avg<10000, 0= acres_avg>10000, acres_avg<1000)	0.339196 *(0.464819)*
Acres_10Kplus	A binary variable indicating if the average acres presented in each study is 10000 acres or greater. (1=acres_avg>10000, acres_avg<10000)	0.065327 *(0.238936)*
Urban	A binary variable indicating if the parcel in question is specified as being located in an urban area (1=urban; 0=rural or unspecified)	0.032663 *(0.171664)*
Prime	A binary variable indicating that the parcel in question is identified as containing prime agricultural soils (1=prime soils indicated; 0= no specification)	0.032663 *(0.171664)*
Unspec_multi	A binary variable indicating that the study did not specify a unique landtype in the choice questions (1=landtype is unspecified, 0= one landtype is defined)	0.013819 *(0.161748)*
Lvstck	A binary variable indicating that the land is specified as dairy, livestock, or crop-based food (1=livestock/food landtype for specific parcel, 0=other)	0.316583 *(0.461972)*
Idle	A binary variable indicating that the land is specified as idle, hay fields, or open space (1=idle/fields landtype for specific parcel, 0=other landtype)	0.221106 *(0.414114)*
Forest	A binary variable indicating that the land is specified as forestry, orchard, or tree-farm land use (1=forest/tree landtype for specific parcel, 0=other landtype)	0.251256 *(0.431781)*
Nursery*	A binary variable indicating that the land is specified as nursery production (1=nursery landtype for specific parcel, 0=other landtype)	0.197864 *(0.387594)*

Trust_pur	A binary variable indicating that the preservation option uses private funding (i.e. trusts) to purchase the parcel. (1=trust outright purchase method, 0=other method)	0.113065 *(0.306824)*
Trust_con	A binary variable indicating that the preservation option uses private funding (i.e. trusts) to apply contracts or easements to the parcel. (1=trust contracts, 0=other method)	0.113065 *(0.306824)*
S_t_pur	A binary variable indicating that the preservation option used public (state or town) funding to purchase the parcel (1=Public-funded outright purchase, 0=other method)	0.263819 *(0.449313)*
S_t_con	A binary variable indicating that the preservation option used public (state or town) funding to apply a contract or easement to the parcel (1=Public contracts, 0=other method)	0.351759 *(0.480762)*
Zone*	A binary variable indicating that the specific parcel will be preserved through changes in zoning regulations (1=zoning method of preservation, 0=other method)	0.158292 *(0.35441)*
No_high*	A binary variable indicating that the specific parcel is not likely to be developed in the next 10 years (includes low, moderate, or unspecified risk) (1=not high risk, 0=high risk)	0.667714 *(0.462214)*
H_risk	A binary variable indicating that the specific parcel is likely to be developed within 10 years (1= high development risk, 0=not high risk)	0.332286 *(0.462214)*
No_access	A binary variable indicating that the parcel will not be accessible to the general public after preservation. (1=no access available, 0=accessible)	0..318925 *(0.466196)*
Moderate_access	A binary variable indicating that the parcel will be accessible for passive recreational activities after preservation (1= moderate access, 0=not accessible or high access)	0.301402 *(0.459001)*
High_access*	A binary variable indicating that the parcel will be accessible for active recreational activities, such as hunting, after preservation (1= hunting access available, 0=not high access)	0.245327 *(0.430407)*
Inc_pop	Median Population income level as reported in the 2000 U.S. Census for each jurisdiction	48330.59 *(6582.304)*
Edu	Percent of the population over the age of 25 with a Bachelor's degree or higher, as reported in the 2000 Census	27.7929 *(10.5624)*
Response_rate	Deliverable survey response rates as reported by the study authors (i.e. percent responded)	39.7798 *(12.2579)*
Growth_pop	Reported as the percent change in population over the years from 1985 to 2000 of U.S. Census data.	23.8081 *(15.5991)*
Area_ac**	Size of jurisdiction reported in acres	3052052.98 *(7534730)*
Density_hh	Housing density reported as the number of housing units per square mile within the jurisdiction, based on 2000 U.S. Census	133.4861 *(87.991)*
Percent_preserved	Percent of the total land area that has been preserved through contracts, purchasing, and other preservation methods (As of 2000).	16.1089 *(8.9184)*

Mlogit	A binary variable indicating that the study methodology used to calculate WTP values was a mixed or multinomial logit. (1=mlogit, 0=other method)	0.359296 *(0.471817)*
Region_south	A binary variable indicating that the study took place in the South Atlantic region of the U.S, where regions were defined according to the U.S. Census. (1=south, 0= other region)	0.396985 *(0.482718)*
Year	An index variable indicating the year in which the survey was implemented. The index is based on the difference of the study year and the reference year 1995 (Range: 1-12)	9.954774 *(2.561325)*
Method_person	A binary variable indicating the method in which the surveys were implemented. (1=in-person; 0=mail=in)	0.022613 *(0.143519)*

*Indicates default in defined model; summaries presented in this table are included to clarify variable specifications
**Indicates a specified variable that Is used in a subsequent calculation of variables within the specified model.

2. Empirical Model

2.1. Model Specifications and Details

Past meta-analyses have incorporated a range of statistical methods, with none universally accepted as superior (Johnston et al. 2006). Prior MRMs, however, often apply semi-log, log-linear, trans-log, or other forms involving log transformations of either dependent or independent variables (Johnston et al. 2005). Advantages of such functional forms can include improved fit to the data and empirical properties that better coincide with theoretical expectations (e.g., Johnston et al. 2005). Log-transformations, for example, can reduce the impact of extreme values in the dependent variables that might otherwise be over-stated in other model specifications (Burbridge et al. 1988).

The current metadata, however, include numerous instances of non-positive WTP estimates. These negative values may be a consequence of statistical fit from the original studies, or they may be reasonable results elicited from the implicit random utility function derived from the responses (Haab and MCConnell 1996). Because there remains the possibility that individuals could reject a referendum, such as a proposal for farmland preservation, even it were free, there is some potential for negative values that still fit logical responses. Therefore, this thesis explores the options to accommodate negative and zero WTP values.

While the problem of negative WTP is debated, its prevalence in discrete choice experiments has resulted in non-consensus within the literature (Haab and McConnell 1996). There are two primary solutions presented to deal with negative WTP values. One solution is to truncate the distribution by eliminating negative values. Removing negative values, however, can intensify the effects of the positive values; increasing the sensitivity of the model changes in the distribution (Haab and McConnell 1996). The second option is to use a distributional transformation to accommodate for all of these values.

The application of log-transformations is common in many studies to accommodate the curvature in the data and define the relationships among attributes as linear rather tan multiplicative. However, because log functional forms are undefined at zero and negative values, the use of such forms would require *ad hoc*, arbitrary adjustments of the dependent variable (Layton 2001). To assume near-zero values for these observations would imply that there are virtually no variations between each of these welfare estimates. The primary purpose of this meta-analysis is to assess the degree of variation across each sample study and the proportion of variation due to specific explanatory variables. Therefore, any substantial degree of adjustments to the WTP estimates could potentially result in significant biases in the meta-regression results and compromise the primary objective of this study.

To avoid potential biases associated with such arbitrary adjustments, but retain desirable properties of non-linear functional forms, an alternative transformation – the inverse hyperbolic sine (Burbridge et al. 1988) – is applied to the econometric model. As described by Burbridge et al. (1988), the inverse hyperbolic sine transformation (IHS) offers a potential modeling solution for data sets containing both positive and negative values, but for which analysts wish to approximate log curvature in estimated relationships.[5] The IHS is a flexible family of curves; symmetric and linear around the origin and approximating a logarithm in the right tail (Layton 2001; Pence 2006).

[5] Another transformation that has been considered for handling extreme or negative dependent variable values is the standard Box-Cox transformation, $(x^{k} - 1)/\lambda$. However, as discussed by Burbridge et al. (1988) and Layton (2001), this function cannot be estimated as λ approaches zero. In our data, and in similar valuation studies, there are variables with values of zero or near-zero. Therefore, this alternative is not applicable for our purposes.

Because the log-likelihood function for the IHS is defined for zero and negative values of the dependent variable, however, this transformation eliminates the need for ad hoc adjustments to welfare values. The first application of the IHS model transformation in the non-market valuation literature is provided by Layton (2001), who illustrates the potential advantages of this function form for stated preference estimation. The following application, however, is the first application of the IHS form to valuation meta-analysis.

Proposed by Johnson in 1949, the general IHS form can be written as:

$$g(x, \theta) = \ln(\theta x + (\theta^2 x^2 + 1)^{1/2})/\ \theta = \sinh^{-1}(\theta x)/\ \theta \qquad (6)$$

where x is the dependent variable to be transformed and θ is a scaling parameter. The function g(x,θ) is symmetric around zero in θ, and typical generalizations of the formula concentrate on values of θ ≥ 0 (Burbridge et al. 1988). Figure 1 illustrates the IHS transformation under the standard form where θ is equal to 1.

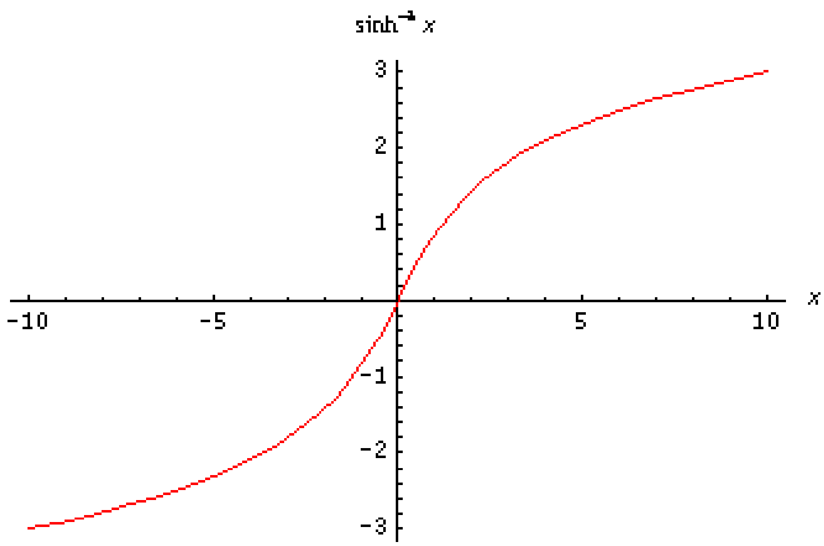

Figure 1. Inverse Hyperbolic Sine Function; *θ =1*

The IHS transformation is linear when θ approaches zero and behaves logarithmically for larger values of θ (Burbridge et al. 1988; Pence 2006). A review of the literature indicates that it is common to assume a standard transformation where θ is equal to one.[6] The standard function, therefore, becomes:

$$G(x \mid \theta=1) = \ln(x + (x^2 + 1)^{1/2}) = \sinh^{-1}(x) \quad (7)$$

Initial estimates of the specified model in this study compared linear, semi-log, and IHS transformations to verify the accuracy and general performance of each functional form. Results indicated that IHS transformations fit the underlying data well and minimized *ad hoc* adjustments; therefore, subsequent analysis continues with the IHS functional form.

In the present case, the standard IHS transformation was applied both to the dependent variable (per acre WTP), and to the explanatory variable characterizing jurisdiction acreage to minimize the impact of extreme acreage values. All other independent variables are linear, leading to a trans-IHS functional form (cf. Layton 2001). Other than the use of the IHS functional form, the econometric model follows standard conventions for meta-analysis; the MRM is estimated as a multi-level model using maximum likelihood estimation with White-corrected standard errors to correct for heteroscedasticity and serial correlation across observations and studies (Rosenberger and Loomis 2001; Bateman and Jones 2003; Johnston et al. 2005).

Initial analysis considers an unweighted and weighted meta-regression model. The weighted model uses the *no_obs_inv* variable as the weight, such that each observation

[6] As mentioned, the first application of the IHS model transformation in the context of environmental resource values was cited in Layton (2001). Here, the author investigated stated preference CV surveys on the value of fish populations. This study also utilizes the standard form of the IHS model, where θ=1.

is given an equal share across all studies. The full meta-regression model is specified as:

$$IHS\_WTP_i = constant + \beta_1 acres\_1to10k + \beta_2 acres\_10kplus + \beta_3 IHSarea + \beta_4 prime + \beta_5 lvstck + \beta_6 forest + \beta_7 idle + \beta_8 unspec\_multi + \beta_9 trust\_pur + \beta_{10} trust\_con + \beta_{11} s\_t\_pur + \beta_{12} s\_t\_con + \beta_{13} h\_risk + \beta_{14} no\_access + \beta_{15} moderate + \beta_{16} inc\_pop + \beta_{17} edu + \beta_{18} urban + \beta_{19} response\_rate + \beta_{20} density\_hh + \beta_{21} growth\_pop + \beta_{22} percent\_preserved + \beta_{23} method\_person + \beta_{24} region\_south + \beta_{25} mlogit + \beta_{26} year \quad (8)$$

where IHS_WTP_i are the estimated and reported WTP values for all 1592 observations and the vector, β_i, includes the estimated parameter coefficients. Following Johnston et al. (2005, 2006), both weighted and non-weighted regression results are illustrated, with weights for the former model defined following Poe et al. (2001), such that the sum of weights for all observations from a given study is equal to one.[7]

a) Expected Signs on Coefficients

Previous empirical studies support the assumption that the average WTP for farmland decreases as the number of acres preserved increases. This diminishing marginal returns effect on WTP is demonstrated in Figure 2. As more acres of preserved farmland are provided, the marginal returns to society diminish.

[7] The literature has not reached consensus over the use of weighted versus unweighted models. Weighted specifications prevent studies that provide multiple observations from unduly influencing model estimation, but also imply that such studies are no more informative, overall, than others (Bateman and Jones 2003). Given the lack of consensus, both specifications are illustrated here.

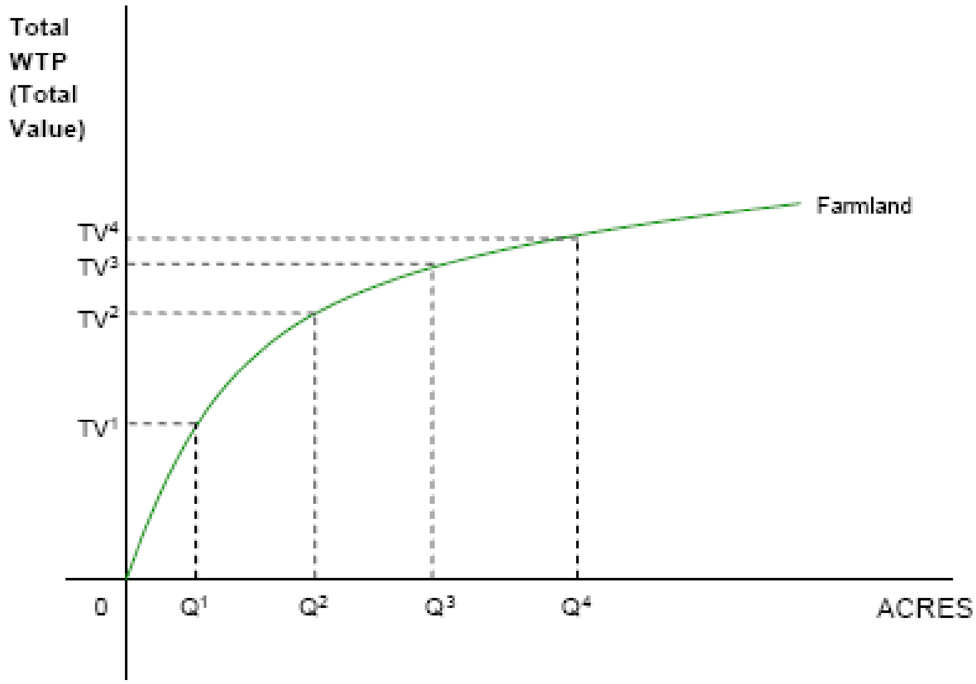

Figure 2: The total WTP for farmland preservation given the change in acreage preserved. Sources: (Bergstrom et al. 1985; Johnston et al. 2001).

Additionally, Duke et al. (2002) and Johnston et.al. (2001) provide statistically significant evidence that, for small incremental changes in the number of acres preserved, the marginal WTP increases at a diminishing rate. If we consider the potential anti-development benefits of farmland preservation, we would expect that the marginal willingness to pay for additional farmland preservation would increase (Bergstrom and Ready 2003). This result is particularly evident where farmland is perceived as being scarce or more at risk for development (Johnston et al. 2001). Based on the theoretical assumptions, therefore, we expect to find an indication that as the quantities of land being preserved increase, the WTP values will be lower. Negative coefficients on the variables *Acres_1to10k* and *Acres_10Kplus* would indicate diminishing marginal WTP for additional preserved acres. Similarly, a negative sign on *IHSarea* is also expected as the WTP for preservation across a larger jurisdiction is expected to be smaller.

The perceived risk of development, itself, is expected to impact WTP values, as not only density, but expected density from additional development plays into individual perceptions of value for farmland. If a parcel of land is at high risk of development, theory suggests that the public would be more willing to support preservation efforts to prevent this additional development. Bergstrom and Ready (2003) explain that high density development, such as strip malls and commercial uses, are less desirable to homeowners than low-density sub-divisional residential development. As a result, an indication of pre-existing development trends coupled with a high risk of additional development should trigger higher marginal WTP responses for preservation programs.

Previous studies also indicate that beyond the desire to preserve open spaces and prevent development, communities support farmland preservation for its rural character. The productivity and the type of farming taking place are as important as having the land preserved itself. These studies show that by indicating the presence of prime soils, individuals' perceptions of land quality increase (Ozdemir 2003; Ozdemir et al. 2004). Indications of productivity and viability, such as prime soils, are expected to have a positive effect on WTP values. Similarly, specified landtypes are also expected to have a significant impact on WTP. For example, studies in the Northeast indicate that livestock and dairy farms were the preferred preservation option (Duke et al. 2002; Johnston et al. 2007; Johnston et al. 2007). However, the signs on each land type relative to the default landtype, nursery, remain ambiguous.

Use values are also expected to influence WTP values. In empirical studies where accessibility is provided, respondents demonstrate a significant increase in their value of preservation (Johnston et al. 2001; Duke et al. 2002; Bergstrom and Ready 2003). These results suggest that the provision for direct use values increases the public value for land. More recent studies also address the divergent impacts of different levels of access on values. High access activities such as hunting or four-wheeling may actually limit the potential enjoyment of open spaces and farmland, and would therefore lead to lower WTP values than lands with moderate accessibility (Bergstrom and Ready 2003; Johnston et al. 2007). A summary of these expected effects are shown in Figure 3.

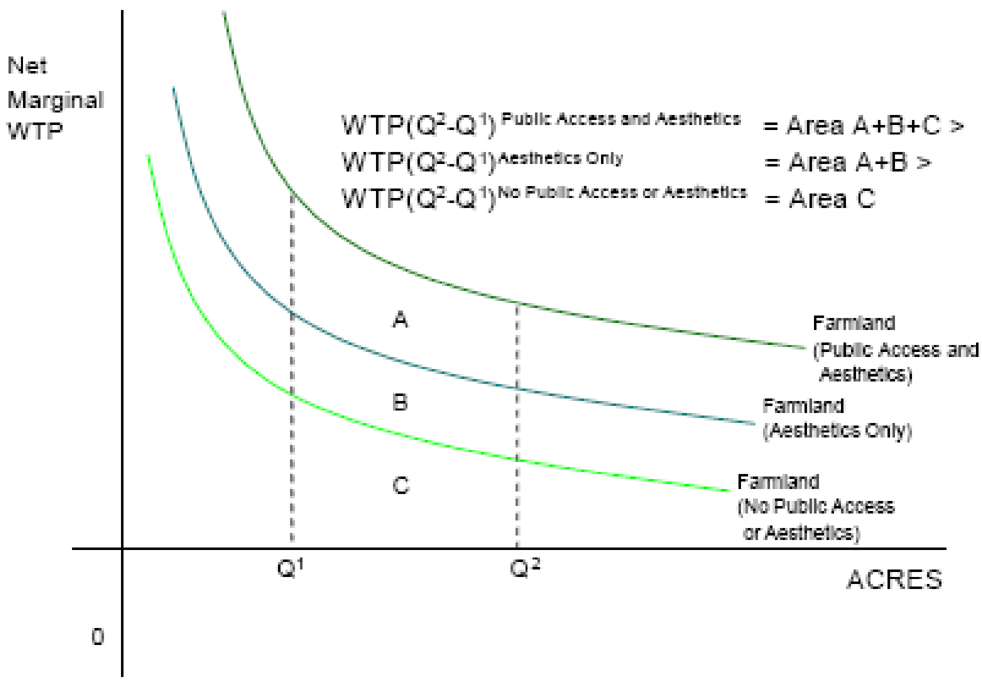

Figure 3. Marginal WTP given changes in acreage and accessibility. Provision of access in addition to non-use amenities in farmland is expected to increase the net marginal WTP value reported in CC and CE studies. Sources: (Bouwer et al. 1995; Swallow 2002; Bergstrom and Ready 2003).

Another attribute that may influence WTP values for farmland preservation is the method of preservation applied to the parcel. Previous studies demonstrate that open space or farmland protected under conservation easements may be less desirable than lands that are publicly owned by the town or state (Swallow 2002; Ready and Abdalla 2003). Similarly, past assessments of public preferences suggest that the public prefers preservation methods that avoid additional regulatory action. In a qualitative phone-survey study, Furuseth (1987) discussed respondents' reaction to farmland preservation programs and their general preference for individual programs over regulatory methods. Johnston and Duke (2007) provide an empirical assessment of systematic preferences for preservation methods. In this study, zoning methods demonstrated a significantly negative impact on expected WTP, where the provision of zoning-based preservation reduced WTP values by $0.4099 to $0.6271 per acre. Therefore, relative to the default method of regulatory zoning, the coefficients for preservation method are expected to be positive.

Finally, the expected signs on the remaining coefficients are ambiguous. Previous studies have indicated that methodological factors of study implementation have significant effects on reported value estimates. However, the expected sign on these coefficients is uncertain.

IV. Results and Discussion

1. Overall Model Assessments and Comments

The results indicate that various attributes are associated with systematic variations in WTP for farmland preservation. Model results are promising with regard to the ability of MRMs to identify systematic components of WTP and reveal patterns not apparent from stated preference models considered in isolation. Revealed empirical patterns in WTP across studies and observations suggest the presence of an underlying meta-valuation function upon which defensible benefit transfers might be grounded.

Full model results are displayed in Table 5. Model 1 is the unrestricted, unweighted model. Model 2 is the weighted version of the unrestricted specification. Likelihood ratio tests indicate that model variables are jointly significant at $p<0.0001$ in both instances (-2 Log Likelihood χ^2 = 1084.96, df = 25 for the unweighted model and χ^2 = 809.91, df=25 for the weighted model). R^2 values computed from ordinary least squares (OLS) variants of the reported models[8] suggest that the estimated models account for a significant proportion of variance in WTP values across observations, particularly as compared to prior meta-analyses in the literature (cf. Johnston et al. 2006). Random effects are not statistically significant in either estimated model.

Initial comparisons between the two models indicate that parameter estimate magnitudes and significance levels are robust to weighted versus unweighted model specifications. This corresponds to findings in prior meta-analyses (e.g., Johnston et al. 2005, 2006). There is significant empirical evidence of systematic variation within WTP values, validating prior expectations that there are particular factors influencing public

[8] Maximum Likelihood random effects models do not provide standard R^2 estimates. Therefore, these reported estimates should be evaluated with caution, as they serve as only approximates of the variations explained by the model.

preferences for farmland preservation. The parameter estimates of the two models are similar, but not equivalent. In general, the significance levels of the parameter estimates are improved in the unweighted model. [9]

[9] The unweighted model has 13 of the 26 coefficients estimates that are significant at $p<0.01$, whereas the weighted model has 12 of the same significant level.

TABLE 5. META-REGRESSION ANALYSIS RESULTS: WEIGHTED AND UNWEIGHTED MODELS

Variable	Model One: Unweighted	Model Two: Weighted (weight = 1/ #obs)
Intercept	2.9171*** (9.83)[a]	2.7533*** (5.41)
Acres_1to10k	-0.3569*** (-8.05)	-0.3442*** (-6.54)
Acres_10kplus	-0.7245*** (-9.30)	-0.6706*** (-8.43)
IHSarea	-0.04166*** (-5.54)	-0.03585** (-2.41)
Prime	0.000212*** (3.13)	0.000226*** (3.62)
Lvstck	0.1036* (1.74)	0.1030* (1.81)
Forest	0.09351 (1.42)	0.07054 (1.18)
Idle	0.07873 (1.41)	0.07964 (1.48)
Unspec_multi	0.09411* (1.69)	0.09031* (1.65)
Trust_pur	0.1142** (2.48)	0.1143** (2.48)
Trust_con	0.07091** (2.06)	0.0701** (2.06)
S_t_pur	0.06646 (1.20)	0.06985 (1.27)
S_t_con	0.1129** (2.06)	0.1095** (1.99)
H_risk	0.06772** (2.43)	0.09034** (2.36)
No_access	-0.2103*** (-3.98)	-0.2621*** (-4.75)
Moderate_access	0.2295*** (3.24)	0.2813*** (4.19)
Inc_pop	-7.5E-6** (-2.34)	-6.43E-6* (-1.72)
Edu	-0.00136 (-1.09)	-0.00064 (-0.41)
Urban	-0.00012** (-2.04)	-0.00013** (-2.43)
Response_rate	0.007554***	0.006315***

	(3.40)	(3.27)
Density_hh	0.000461*** (2.80)	0.000265*** (2.64)
Growth_pop	0.006755*** (11.07)	0.005988*** (4.54)
Percent_preserved	0.002832 (1.05)	0.002053 (0.80)
Method_person	-1.3032*** (-13.81)	-1.644*** (-9.81)
Region_south	-0.1240*** (-3.04)	-0.1098*** (-3.03)
Mlogit	0.009816 (0.32)	-0.00293 (-0.16)
Year	-0.2184*** (-9.33)	-0.2073*** (-6.96)
-2 Log-Likelihood χ^2	1084.96 (25)	809.91 (25)
R^2 (OLS)	0.6979	0.7237
N	1592	1592

[a]Value under parameter estimates are t-values
*Denotes significance at p < 0.1
**Denotes significance at p < 0.05
***Denotes p <0.01

1.1. Consistency with Theoretical Expectations: Value Surface Tests

Empirical results provide clear evidence of value surfaces that correspond to prior findings and theoretical expectations. Of 26 parameter estimates in the model, 20 are statistically significant at p<0.10 or better. Revealed empirical patterns in WTP across studies and observations suggest the presence of an underlying meta-valuation function or value surface (Rosenberger and Phipps 2007) upon which defensible benefit transfers might be grounded.

THE INFLUENCE OF SCOPE AND SCALE ON VARIATIONS IN WTP

Variable	Estimate (T-value)
Intercept	2.9171*** (9.83)[a]
Acres_1to10k	-0.3569*** (-8.05)
Acres_10kplus	-0.7245*** (-9.30)
IHSarea	-0.04166*** (-5.54)

For example, empirical results suggest that WTP values are sensitive to both and scale scope (i.e., the quantity of land preserved and the size of the jurisdiction within a given amount of land is preserved, respectively). These findings extend similar meta-analytic results for other natural resources (e.g., Smith and Osborne 1996; Johnston et al. 2005, 2006). In this case, larger preserved areas are associated with lower WTP/acre values. Relative to the default case in which less than 1000 acres are preserved, WTP/acre is successively smaller for preservation acreages between 1000 and 10,000 acres (*Acres_1to10k*) and over 10,000 acres (*Acres_10kplus*). These findings reflect expected patterns of diminishing marginal utility of preservation.

Results also suggest an influence of jurisdictional size (*IHSarea*) on WTP/acre, where the larger the area in which the preservation will occur, the less respondents are willing pay. These results validate prior small sample findings of Johnston and Duke (2007). For example, one might expect lower WTP/acre when farmland is preserved somewhere within a respondent's home state compared to otherwise identical preservation implemented somewhere within a respondent's home community, in part because of the lesser degree of expected proximity to preserved land preserved within larger jurisdictions and reduced expectations of use values (Johnston and Duke 2007).

THE INFLUENCE OF LAND USE CHARACTERISTICS ON VARIATIONS IN WTP

Variable	Estimate (T-value)
Prime	0.000212*** (3.13)
Lvstck	0.1036* (1.74)
Forest	0.09351 (1.42)
Idle	0.07873 (1.41)
Unspec_multi	0.09411* (1.69)

Results also validate the findings of some earlier valuation studies that predominant land use can influence WTP for preservation, but that land type may not be a dominant consideration in some contexts (Johnston and Duke 2007; Bergstrom and Ready 2005). As shown in the table above, the significant and positive coefficient on prime farmland soils is consistent with earlier findings that higher WTP may be associated with such productive soil types (Bergstrom et al. 1985), while the lack of statistical significance for the majority of land type parameter estimates also corresponds to prior findings that farmland type may not always be significant determinant of welfare impacts (e.g., Johnston and Duke 2007). This result indicates that, in addition to production type, residents prefer preservation programs that target prime agricultural soils that can potentially contribute to the quality of production taking place.

THE INFLUENCE OF PRESERVATION METHODS ON VARIATIONS IN WTP

Variable	Estimate (T-value)
Trust_pur	0.1142** (2.48)
Trust_con	0.07091** (2.06)
S_t_pur	0.06646 (1.20)
S_t_con	0.1129** (2.06)

In addition to land type characteristics, the method in which land is preserved determines public preferences (Bergstrom and Ready 2005; Duke and Johnston 2008). Results also validate prior single-study findings that preservation methods can exert statistically significant influences on WTP (Johnston and Duke 2007, 2008). For example, relative to the default of zoning or regulatory methods, WTP/acre is greater for preservation accomplished using government conservation easements (*s_t_con*), land trust conservation easements (*trust_con*), or land trust outright purchase (*trust_pur*); all these effects are statistically significant. However, results do not suggest a statistically significant difference in WTP between regulatory methods and outright purchase by government agencies (*s_t_pur*).

THE INFLUENCE OF PUBLIC ACCESS ON VARIATIONS IN WTP

Variable	Estimate (T-value)
No_access	-0.2103*** (-3.98)
Moderate_access	0.2295*** (3.24)

Non-market valuation theory states that potential use values should increase WTP values. Considering expectations based on prior findings (Duke et al. 2002; Bergstrom and Ready 2005; Johnston and Duke 2007), public access has a large and highly significant effect on WTP, with moderate access more highly valued than other access alternatives. Preservation offering no access is the least preferred. Preservation offering non-passive “high” access – such as hunting or four-wheeling – is preferred to no access, but not preferred to moderate levels of access. Considering that some residents might perceive hunting or off-road vehicles as risky or having negative impacts on other amenities – aesthetic and environmental quality, for example – it is not surprising that high-level access is not dominantly preferred. Such patterns in public preferences for access mirror findings in prior research both in the farmland and non-farmland literature (e.g., Johnston et al. 2002; McGonagle and Swallow 2005; Johnston and Duke 2007, 2008). Specifically, prior research often finds that public access is associated with statistically significant welfare improvement, but that welfare gains are greatest for moderate—as opposed to more extensive—levels of access.

THE INFLUENCE OF JURISDICTIONAL CHARACTERISTICS ON VARIATIONS IN WTP

Variable	Estimate (T-value)
Density_hh	0.000461*** (2.80)
Growth_pop	0.006755*** (11.07)
Percent_preserved	0.002832 (1.05)
H_risk	0.06772** (2.43)
Region_south	-0.1240*** (-3.04)
Urban	-0.00012** (-2.04)

Directing attention to socio-economic factors on public preferences, value surfaces related to policy context—including the presence of potential substitutes and complements—also follow theoretical expectations. For example, empirical results suggest that WTP/acre is greater for preservation that occurs in more densely-populated jurisdictions. This is an expected pattern related to the perceived scarcity of farmland in densely populated areas. Similarly, indicators of population growth, development rates and risk of development are associated with systematic increases in WTP.

Interestingly, willingness to pay values are highly correlated with density (*Urban; density_hh*). A possible explanation for this result is that farmland in a densely-populated area may be viewed as ill-placed or less viable than larger agrarian communities away from urban centers. This result also suggests that the public values the preservation of rural communities. In general, large tracts of conjoining parcels may be seen as more productive agricultural production than a single small parcel in a highly developed area. Additional location-specific results indicate that parcels in southern regions receive less value for preservation than farmlands in the north and northeast. This result appears congruent with current farmland preservation policies, as the northeast has experienced high rates of development, triggering early preservation policies.

THE INFLUENCE OF POPULATION CHARACTERISTICS ON VARIATIONS IN WTP

Variable	Estimate (T-value)
Inc_pop	-7.5E-6** (-2.34)
Edu	-0.00136 (-1.09)

Population characteristics demonstrate some significant impacts on WTP. The effect of income is statistically significant but counterintuitive in sign (negative). The reason for this finding is unknown, but is robust across various model specifications. While these results might suggest that, perhaps, farmland is considered an inferior good, it is also possible that these results are due to either measurement error in the income variable or unintended correlation between income and other excluded factors. The income variable was calculated using census data in each jurisdiction from a base of year 2000 dollars; an instrument chosen because adequate measures of respondents' income and education levels were not available from all source studies. The census-based income instrument, therefore, is subject to a measurement error in defining respondent incomes. It is also possible that lower-income jurisdictions may be associated with systematic preference or land use patterns that are not otherwise captured in the model specification.

THE INFLUENCE OF METHODOLOGY ON VARIATIONS IN WTP

Variable	Estimate (T-value)
Response_rate	0.007554*** (3.40)
Method_person	-1.3032*** (-13.81)
Mlogit	0.009816 (0.32)
Year	-0.2184*** (-9.33)

Finally, as found in numerous prior meta-analyses and discussed by Johnston et al. (2006b), Moeltner et al. (2007) and others, results indicate systematic variation of WTP associated with methodological attributes of study implementation and design. These results imply that the ways in which stated preference surveys are implemented can have a direct impact on welfare estimates. Specifically, this analysis finds that both year of survey implementation and the method of distribution have statistically significant impacts on public values estimates.

2. Benefit Transfer Applications and Performance

A secondary focus of this study is to investigate the use of meta-analysis to inform and improve benefit transfers in farmland preservation policies. The meta-regression serves as an estimated benefit function from which WTP values can be forecasted.

There remain opposing opinions on the validity of meta-analytical results for benefit transfer (Smith and Pattanayak 2002). Although there is widespread agreement concerning the ability of MRMs to illuminate relevant value surface patterns, there is less consensus regarding the direct use of such models for benefit estimation and transfer. While some caution against the direct application of meta-analysis for welfare estimation (e.g., Poe et al. 2001, US EPA 2007) other researchers note the potential of MRMs to provide reduced error benefit transfers in many policy contexts (e.g., Johnston et al. 2005; Moeltner et al. 2007; Rosenberger and Phipps 2007; Shrestha et al. 2007). Through the use of validity tests, we can compare the predicted values from the meta-regression and determine it they are able to accurately predict the observed WTP values.

This thesis presents in-sample and simulated out-of-sample validity tests to illustrate expected errors from this benefit function and evaluate errors for policy implications.

2.1. Transfer Methods and Tests for Assessing Transfer Errors

Validation of benefit function transfers begins by predicting values from the available site-specific data. Each predicted value is obtained using a forecasting function; in this case the meta-regression benefit function. In-sample predictions are obtained by adding up the relevant coefficients for each attribute and average jurisdiction characteristic. Essentially selecting one observation from the dataset, this method generates errors based on the ability of the meta-regression model to predict the actual selected value. To calculate transfer errors, each of these predicted values are subtracted from the original WTP estimates from the study sites. The transfer error is expressed by the general formula:

$$\text{Transfer Error} = P_i - V_i \qquad (9)$$

where P_i is the i^{th} predicted value for the policy site, determined by the benefit function, and V_i is the corresponding original value from the study site observation. Transfer error values are represented as dollar values, as the observed and estimated values are expressed as total amount WTP per acre, per household, per year.

These raw transfer errors, however, do not provide substantial detail in terms of the magnitude of error and relative efficiency within the benefit transfer that is performed. By expressing the transfer errors as a percent error in addition to the raw values, the relative success of the benefit function's transferability becomes clear. We can express this percent error as:

$$\%\ \text{Transfer Error} = \frac{P_i - V_i}{V_i} \qquad (10)$$

To demonstrate an example of a single point transfer, consider the Town of Brooklyn, Connecticut, where a preservation program for a high risk 100 acre dairy farm is identified for preservation. The parcel would be preserved through a conservation easement by the town, and following the easement provisions, this parcel would allow passive public access. Using the actual population and land use attributes for Brooklyn, and assuming the mean values for methodological attributes from the metadata, the meta-regression benefit function predicts a household willingness to pay of $1.27. This prediction is obtained by adding the coefficients for livestock, high risk, moderate access, and town easement as well as the average jurisdictional characteristics of the town of Brooklyn. In the sample metadata, the actual estimates WTP per acre household WTP was $1.35. This translates into a 6.03% transfer error for this in-sample example.

There are different methods for comparing aggregate transfer errors across samples, including mean absolute value errors and trimmed mean errors. The benefit transfer literature lacks a consensus on which error estimation method provides the most accurate information (Shrestha and Loomis 2003). Therefore, this thesis initially conducts three typical in-sample estimations and compares overall results. Later sections also present a fourth repeated-sampling method to contrast against in-sample approaches. These various calculations are discussed in more detail below.

2.2. Transfer Error Results

The following Tables (6 through 8) illustrate the performance of the meta-regression benefit transfer approaches using mean in-sample WTP predictions. The first column presents the actual mean WTP/acre value for each jurisdiction as reported from the original metadata. It is important to present alternative measures of transfer error, as one method of calculation may not reveal robust policy-relevant results. For example, a percentage error provides a sense of scale of errors relative to previously elicited percent errors in earlier studies. An error that is high relative to these earlier results but, these percent errors may consequently eliminate feasible results. Even if the actual value error was within $0.01 of the original value, the percent value may reveal very significant errors and discount the benefit transfer as invalid. Yet, for specific policy contexts, a $0.01 error margin may actually be acceptable. Therefore, the primary benefit transfer tables report three alternative measures of transfer error to compare these results.

The mean predicted WTP in the second column reports the average WTP predicted by the meta-regression based on the average jurisdictional parameter values and individual preservation option characteristics for each of these values. The mean of the difference between these estimated and predicted values are reported as mean absolute value errors in the third column. Absolute transfer errors present a more rigorous description of the overall efficiency of the transfer because they eliminates the diminishing impact of negative difference in estimates on the mean errors.

An alternative estimate of absolute percent transfer errors is also included. These absolute transfer errors are specified as the trimmed mean percent error, where results are reported after trimming 5 percent of the observations in each jurisdiction. The percent error results are trimmed such that the highest and lowest 2.5 percent of the estimated WTP values were discarded from the data pool before calculating the transfer error. The purpose of trimming the means is to minimize the effect of outlier observations on the average. This percent error is reported in the fourth column.

The “Comparison Trimmed Mean” column presents a final alternate specification for transfer error estimates. This mean-value approach comparison is included to demonstrate the variation in percent transfer errors that is possible based upon another well-supported method. This particular estimate is based upon the sample advisory from the Environmental Protection Agency’s Science Advisory Board (EPA SAB). In this thesis, we use mean values across similarly-scaled preservation studies as the estimated WTP value in each jurisdiction. Predicted values are then taken from this mean estimate and used to estimate errors by comparing predictions within individual jurisdictions instead of across the entire data set. Rather than examining WTP estimates provided across the entire panel of data, this method further limits the impact of outliers on average error estimates by restricting observations to comparable jurisdiction sizes.

TABLE 6. TOWN IN-SAMPLE BENEFIT TRANSFER RESULTS					
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean Absolute Value Error	Absolute Value % Error (5% Trimmed Mean)	Comparison: Trimmed Mean Absolute Value % Error
Woodstock, CT	$0.35	$0.37	$0.32	86.64%	182.72%
Pomfret, CT	$0.40	$0.27	$0.23	72.39%	354.72%
Brooklyn, CT	$0.49	$0.40	$0.14	37.83%	111.89%
Thompson, CT	$0.23	$0.22	$0.33	70.54%	153.86%
Smyrna, DE	$0.37	$0.33	$0.17	76.12%	204.31%
Georgetown, DE	$0.61	$0.37	$0.24	116.33%	247.63%
Preston, CT	$0.44	$0.56	$0.12	20.96%	44.68%
Mansfield, CT	$0.69	$0.61	$0.25	66.22%	88.18%

TABLE 7. STATE IN-SAMPLE BENEFIT TRANSFER RESULTS					
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean Absolute Value Error	Absolute Value % Error (5% Trimmed Mean)	Comparison: Trimmed Mean Absolute Value % Error
CT (1)	$0.012	-$0.037	$0.17	2535.53%	112.01%
CT (2)	$0.0053	-$0.037	$0.17	4078.72%	151.84%
DE	$0.0062	-$0.035	$0.17	3069.60%	94.37%
ME	$0.0003	$0.03	$0.06	33,625.05%	4271.88%
GA (1)	$0.00005	-$0.04	$0.05	310,924.00%	42,823.90%
GA (2)	$0.0002	-$0.03	$0.04	28,205.82%	4554.67%
OH	$0.00002	-$0.09	$0.09	104,428.77%	6149.50%

TABLE 8. COUNTY IN-SAMPLE BENEFIT TRANSFER RESULTS					
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean Absolute Value Error	Absolute Value % Error (5% Trimmed Mean)	Comparison: Trimmed Mean Absolute Value % Error
Kent County, DE	$0.02	-$0.06	$0.08	10,585.16%	51,308.18%
Sussex County,	$0.01	-$0.05	$0.07	902.77%	5658.65%
New Castle County, DE	$0.02	$0.04	$0.06	949.84%	8265.44%

2.3. Implications and Comparisons to Past Findings

The results indicate that, for community transfers, the meta-analysis performs well in predicting valid benefit estimates, relative to earlier error estimates in benefit transfer literature (Bergstrom 2004). These results suggest comparable transfer performance relative to past results in the literature, where transfer errors reported typically fell below 200 percent (Rosenberger and Stanley 2006). These results might be suitable for applied use depending on the level of welfare precision required. They are also similar in magnitude to site-to-site function based transfer errors for farmland preservation values estimated by Johnston and Duke (2008).

In state-level transfers, however, demonstrate limitations in the meta-regression benefit function's ability to provide estimates that fall within previous reported scales and minimize transfer errors. These poor results suggest that there is an inherent difficultly in accurately predicting smaller WTP values. In the state of Georgia, for example, mean WTP varied from $0.00005 to $0.0002 per acre (Ozdemir 2002; Volinsky and Bergstrom 2004). State studies produce small per acre welfare values, in part, because preservation options presented in state scale survey scenarios often reflect large acreages. As a result, per acre WTP estimates are small, at least in part due to diminishing marginal utility of preservation (cf. Johnston and Duke 2007). Respondents do not know where the preservation of land will occur when they are asked to vote for preservation; therefore, their perceived values for these lands may be markedly less than preservation within their respective towns.

a) Repeated-sample Benefit Transfers

The following section characterizes the magnitude of transfer errors that might result from the current MRM, based on leave-one-out, cross-validation tests of transfer error (cf. Layton 2000; Stapler and Johnston 2007).

Assessment of benefit transfers includes not only examining the mean value and percent errors, but also the potential for underlying factors that may have contributed to overall validity. An alternative transfer error estimation method employs a modified leave-one-out cross-validation repeated sampling approach employed by Johnston et al. (2006). This cross-validation method generates predicted values for each preservation option in every jurisdiction based on estimated generalization errors from the sample; thereby, simulating out-of-sample performance estimates (Layton 2000). Compared to the in-sample approaches defined in the previous section, cross-validation provides a more rigorous assessment of transfer validity by testing estimates for every individual observation. By eliminating the subjective researcher decision to hold out a sample and predict its estimate, additional bias from *ad hoc* procedures are reduced (Shrestha and Loomis 2003). If all observations from the metadata are included in the prediction, the efficiency of these results is improved; thereby reducing potential impacts on transferability as well.

To illustrate the cross-validation convergent validity test, assume that one has metadata with n=1…N unique observations. The first step in the leave-one-out testing framework is the omission of the nth observation from the metadata, which is the same as a hold-out sample comprised of a single observation. The MRM is then fitted (i.e., parameters are estimated) using the remaining N-1 observations. This is then iterated for each n=1…N observation, resulting in a vector of N unique parameter estimates, each corresponding to the omission of the n^{th} observation (Efron and Tibshirani 1993).

For each n=1…N observation, the n^{th} observation is not part of the metadata during estimation of the n^{th} model iteration. Parameter estimates for the n^{th} model iteration are then combined with independent variable values for the n^{th} observation (omitted in that model iteration) to generate a WTP forecast for the omitted, and hence out of sample, n^{th}

observation. As MRM results are only used to forecast WTP for the *n*th observation omitted from each estimated model, the result is *N* out-of-sample WTP forecasts, each drawn from a unique MRM estimation. Transfer error is assessed through comparisons of the predicted and actual WTP value for each *N* observations.

Following common convention, transfer error is quantified as a percentage divergence of transfer estimates from the actual study site value for each observation (Rosenberger and Stanley 2006). Percent errors in WTP/acre are presented as an average absolute value over all *N*=1592 observations. Results are presented as trimmed means (5%) to offset the effects of a small number of outliers. These occur in relatively rare instances of near-zero actual WTP estimates, such that even very small magnitude transfer errors represent very large, outlying percentages.

The following Tables 9 through 11 report average percent errors, absolute percent errors and a 5-percent trimmed absolute error for comparison following the method used in the in-sample transfers. Results are disaggregated by the political jurisdictional size of corresponding observations (community, county, state).

TABLE 9. TOWN CROSS-VALIDATION BENEFIT TRANSFER RESULTS				
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean Absolute Value Error	Absolute Value % Error (5% Trimmed Mean)
Woodstock, CT	$0.35	$0.38	$0.302	83.33%
Pomfret, CT	$0.40	$0.41	$0.395	33.06%
Brooklyn, CT	$0.49	$0.29	$0.109	72.84%
Thompson, CT	$0.23	$0.24	$0.311	74.69%
Smyrna, DE	$0.37	$0.37	$0.272	76.93%
Georgetown, DE	$0.61	$0.56	$0.596	20.02%
Preston, CT	$0.44	$0.40	$0.348	94.94%
Mansfield, CT	$0.69	$0.61	$0.471	53.90%

TABLE 10. STATE CROSS-VALIDATION BENEFIT TRANSFER RESULTS				
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean Absolute Value Error	Absolute Value % Error (5% Trimmed Mean)
CT (1)	$0.012	$0.0073	$0.0020	1887.21%
CT (2)	$0.0053	$0.0074	$0.0022	3308%
DE	$0.0062	$0.0091	$0.0029	2707.98%
ME	$0.0003	$0.0647	$0.0673	30675.72%
GA (1)	$0.00005	$0.000083	$0.0013	33262.36%
GA (2)	$0.0002	-$0.0048	$0.0062	4418.79%
OH	$0.00002	-$0.0587	$0.0786	27713.74%

TABLE 11. COUNTY CROSS-VALIDATION BENEFIT TRANSFER RESULTS				
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean Absolute Value Error	Absolute Value % Error (5% Trimmed Mean)
Kent County, DE	$0.02	-$0.0218	$0.0347	1478.38%
Sussex County, DE	$0.01	-$0.0185	$0.0289	405.08%
New Castle County, DE	$0.02	$0.0842	$0.0692	598.24%

Full model cross-validation results indicate transfer error continues to vary markedly across jurisdictional sizes, with community-level transfers universally and substantially out-performing state transfers. There is some marginal improvement in transferability for some jurisdictions. For example, most state absolute transfer errors improved by an order of magnitude; however, the overall error results continue to reflect unacceptable limits of transfer error for potential policy applications. Furthermore, smaller states, such as Connecticut and Delaware, actually performed worse in the repeated-sample transfers compared to in-sample transfer errors.

Nevertheless, state scale errors range from 1887.21% to 33,262.36%, implying transfers are likely unacceptable for applied welfare estimation. These poor state scale results suggest difficulty in accurately predicting small magnitude WTP values. These preliminary validity tests demonstrate evidence that it may be undesirable to stack data from different jurisdictional sizes.

3. Split Model Regressions

The relatively poor performance of state scale transfers raises the question regarding the appropriateness of pooling observations from different jurisdictional scales within a single MRM. To assess this possibility, we split the metadata into two subsets—one including only state scale observations and another including only community and county observations. Independent, split-sample MRMs are estimated for each dataset, with transfer errors again estimated as detailed above. As above, the MRM is estimated as a multi-level model using maximum likelihood estimation with White-corrected standard errors, with a trans-IHS functional form. Unweighted model results are illustrated.

Considering the limited degrees of freedom available with a split sample, however, certain explanatory variables were omitted. In many cases, the choice of omitted variables was determined by the split sample dataset alone. For the model considering only town and county-level studies, variables such as *Acres_1to10K* and *Acres_10Kplus* were irrelevant to the data, as the size of potential parcels was limited to farms under 1000 acres. Similarly, the acreage variables for fewer than 1000 acres were omitted for the state-level data. Additional model specification decisions are discussed in the sections below.

a) States-Only Model

The states-only model considers seven individual studies, resulting in 644 observations. The model specification defined for the metadata available can be written as:

$$IHS\_WTP_i = constant + \beta_1 acres\_1to10k + \beta_2 prime + \beta_3 lvstck + \beta_4 forest + \beta_5 idle + \beta_6 unspec\_multi + \beta_7 trust\_pur + \beta_8 trust\_con + \beta_9 s\_t\_pur + \beta_{10} s\_t\_con + \beta_{11} h\_risk + \beta_{12} no\_access + \beta_{13} moderate + \beta_{14} inc\_pop + \beta_{15} urban + \beta_{16} growth\_pop + \beta_{17} percent\_preserved + \beta_{18} mlogit \quad (11)$$

Compared to the full model, the states-only meta-regression omits seven independent variables due to lack of sufficient variation within the state sample, insufficient degrees of freedom (particularly for dummy variables whose values are constant across all observations from one or more studies), or lack of statistical significance. As mentioned, default acreage variables on parcels less than 1000 acres were eliminated; resulting in a new default variable *Acres_10kplus.* The variable *IHSarea* was also dropped as a result of low statistical significance in previous model testing and the decision to emphasize the potential effects of remaining variables. Similar reasoning resulted in dropping the education variable. The variable for in-person survey sampling was omitted because there were no in-person samples in statewide studies. The variables for year and density of housing units were eliminated due to perfect multicollinearity in these variables within the split dataset. Table 12 summarizes the model results.

TABLE 12. STATE-ONLY META-REGRESSION RESULTS

Variable	States-only Model
Intercept	0.1110 (1.01)[a]
Acres_1to10k	0.06169 (1.32)
Prime	0.00212*** (3.13)
Lvstck	0.004149*** (4.73)
Forest	0.006950*** (2.96)
Idle	0.005062*** (2.82)
Unspec_multi	0.004882*** (3.64)
Trust_pur	0.01590*** (2.68)
Trust_con	0.01519*** (6.15)
S_t_pur	0.008320*** (6.17)
S_t_con	0.01025*** (9.95)
H_risk	0.006036*** (11.21)
No_access	-0.01017*** (-7.31)
Moderate_access	0.001421* (1.64)
Inc_pop	-3.08E-6 (-1.13)
Urban	-0.00012 (-2.04)
Growth_pop	0.000114 (1.13)
Percent_preserved	-0.00137 (-1.12)
Mlogit	0.000146 (1.59)
-2 Log-Likelihood χ^2	881.04 (18)
R^2 (OLS)	0.7170
N	644

[a]Value under parameter estimates are t-values
*Denotes significance at $p < 0.1$
**Denotes significance at $p < 0.05$
***Denotes $p < 0.01$

Despite the limited sample size, there are interesting results from the states-only model. With two-thirds of the variables still indicating significant results, the state-only model demonstrates that there is little influence from methodological factors on WTP outcomes. Specific characteristics on land use and related attributes, however, contribute significantly to the variation in WTP values across the studies. The type of agricultural production and the method in which these lands are preserved were among the largest contributors to welfare estimates; each of which revealed positive preference for the default attributes.

High risk remains positive and highly significant. The lack of accessibility, however, significantly reduces estimates of public values. Surprisingly, moderate accessibility was only somewhat significant; although this attribute still had a positive impact on the expected value outcomes. One potential explanation is that both moderate and high-access are preferred over non-access; yet, the public demonstrates no outward preference for what type of access. If we consider the nature of a statewide survey, these results make intuitive sense. Residents are asked to vote on the preservation of large tracts of land somewhere within the state, but they do not know exactly where that land will be situated. A large tract of land adjacent to a forest or open area may be valuable for high access uses such as hunting. While high access could obviously be detrimental to a local vegetable farm, the lack of precise information on location and scope reveal that the public does not wish to restrict preservation programs on parcels that provide any kind of access.

b) State-level Benefit Transfers

The results of the in-sample benefit transfers for the state-only model are reported in Table 13. Benefit Transfer comparisons at the state level demonstrate some improvements in overall transferability of values. Split-sample benefit transfers are reported following procedures defined in previous sections. Mean predicted WTP values are reported in the same mode, with average predicted values defined across each individual jurisdiction in the split-sample. Mean absolute value errors are presented beside original full sample results, and trimmed absolute value percent errors are also reported.

TABLE 13. STATES-ONLY MODEL IN-SAMPLE BENEFIT TRANSFER RESULTS

JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean WTP (Split Model Predicted)	Absolute Value % Error (Full Model Mean)	Absolute Value % Error (Split Model Mean)
CT (1)	$0.012	-$0.037	**-$0.034**	2535.53%	**1193.31%**
CT (2)	$0.0053	-$0.037	**-$0.009**	4078.72%	**1757.97%**
DE	$0.0062	-$0.035	**-$0.05**	3069.60%	**2000.44%**
ME	$0.0003	$0.03	**$0.04**	33,625.05%	**33,787.78%**
GA (1)	$0.00005	-$0.04	**$0.04**	310,924.00%	**183,099.5%**
GA (2)	$0.0002	-$0.03	**$0.03**	28,205.82%	**34,448.11%**
OH	$0.00002	-$0.09	**$0.03**	104,428.77%	**50,770.1%**

Compared to initial in-sample errors, these split-sample results are varied. Although some state estimates resulted in notably lower transfer errors, other transfers continued to perform poorly. In most cases, changes in transfer errors remained within the same order of magnitude, indicating that, despite splitting the sample, the transferability of values across larger jurisdictions remains uncertain. All jurisdictions exhibit transfer errors well beyond acceptable transfer errors reported in similar studies (Brouwer and Spaninks 1999).

Following the same leave-one-out cross-validation technique from the full regression model, the comparative transfer error results are reported in Table 14. Considering the split-sample results for individual jurisdictions, it appears that repeated sampling techniques improve transfer errors in comparison to in-sample transfers. Mean predicted values are significantly closer to the actual observed mean WTP values from the data. This finding is verified by the notable improvement in all but one jurisdiction. Considering state-only transfers, we now see that at least three of the states within this sample produce transfer errors within historically revealed levels from this cross-validation technique. Furthermore, larger states demonstrate substantial improvements in transferability, with transfer errors decreasing by at least one order of magnitude in most cases. The state of Georgia, however, continues to produce significantly larger errors due to the low WTP observations in the dataset; where a small margin of error can result in large differences in transfer performance.

TABLE 14. STATES-ONLY MODEL CROSS-VALIDATION BENEFIT TRANSFER RESULTS

JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean WTP (Split Model Predicted)	Absolute Value % Error (Full Model Mean)	Absolute Value % Error (Split Model Mean)
CT (1)	$0.012	$0.0073	**$0.0088**	1887.21%	**70.45%**
CT (2)	$0.0053	$0.0074	**$0.0088**	3308%	**125.84%**
DE	$0.0062	$0.0091	**$0.0062**	2707.98%	**87.60%**
ME	$0.0003	$0.0647	**$0.0003**	30675.72%	**589.70%**
GA (1)	$0.00005	$0.000083	**$0.00008**	33262.36%	**2291.01%**
GA (2)	$0.0002	-$0.0048	**$0.0002**	4418.79%	**851.45%**
OH	$0.00002	-$0.0587	**$0.0002**	27713.74%	**2675.41%**

Comparing full meta-regression results to individual result elicited from split-samples, we see that transferability improved for all states in the cross-validation technique. For example, the large outlying error from the state of Georgia in the full model was reduced from 33262.36% down to 2291.01%. Similarly, Connecticut transfers revealed substantial improvement, with transfer errors well within an acceptable range at 70.45% error. These results demonstrate that for state-to-state benefit transfers, a meta-regression analysis method may be more suitable with metadata limited to statewide study sites. Nevertheless, it is also important to note that despite the magnitude of improvement in transferability, overall transfer errors for states remain extremely high. Overall, the largest jurisdictions in this sample still produce the largest transfer errors; supporting the assumption that transfer in larger regions should be performed with a degree of caution. The ability to transfer value estimates across such large demographic regions seems to present problems due to either extremely small WTP per acre values or variations in unobservable attributes.

c) Community-level Model

The following model considers only town and county local effects on WTP values. This split-sample dataset considers 11 individual studies, with a total of 948 observations. The model tested model is specified as:

$$\begin{aligned} IHS\_WTP_i = {} & constant + \beta_1 acres\_1000 + \beta_2 IHSarea + \beta_3 lvstck + \beta_4 forest + \beta_5 idle + \\ & \beta_6 unspec\_multi + \beta_7 trust\_pur + \beta_8 trust\_con + \beta_9 s\_t\_pur + \beta_{10} s\_t\_con + \\ & \beta_{11} h\_risk + \beta_{12} no\_access + \beta_{13} moderate + \beta_{14} inc\_pop + \beta_{15} growth\_pop + \\ & \beta_{16} percent\_preserved + \beta_{17} method\_person \qquad (12) \end{aligned}$$

As with the state-only model, the town and county model was specified in attempt to maintain the integrity of the full meta-regression model. Likewise, the split dataset allowed for immediate elimination of a number of variables. While unsubstantiated omissions can contribute to significant biases in the model results, well-supported elimination of variables contributes to robust results while maintaining sufficient degrees of freedom. Overall, four independent variables were omitted due to lack of variation, degrees of freedom, or statistical significance.

Final model results are reported in Table 15. Acres greater than 1000 were not considered for this model; therefore, the new default variable becomes *Acres_100*, or less than 100 acres preserved. Prime farmland was not an attribute specified among town studies. Similarly, the variable for urban-based preservation could be eliminated from the model because this context was not applicable for smaller communities. The variable *response_rate* was insignificant in previous model testing and therefore eliminated from the model. The variables for region and *mlogit* methodology were also dropped because these were not sources of variation within these studies. Finally, the variable for year did not demonstrate statistically significant contributions to the WTP values.

TABLE 15. COMMUNITY-LEVEL META-REGRESSION RESULTS

Variable	Towns and Counties Model
Intercept	1.5277** (3.68)[a]
Acres_1000	0.4158*** (7.87)
IHSarea	-0.3250*** (-6.04)
Lvstck	0.1798* (1.96)
Forest	0.1617* (1.61)
Idle	0.1334 (1.50)
Unspec_multi	0.1780** (1.99)
Trust_pur	0.2186*** (3.73)
Trust_con	0.1114** (2.33)
S_t_pur	0.1133 (1.34)
S_t_con	0.1752** (2.34)
H_risk	0.1026*** (2.62)
No_access	-0.3145*** (-7.13)
Moderate_access	0.3546*** (4.75)
Inc_pop	-7.51E-6* (-1.78)
Growth_pop	0.005335*** (4.88)
Percent_preserved	0.01217*** (4.72)
Method_person	-0.5125*** (-7.66)
-2 Log-Likelihood χ^2	1247.02 (16)
R^2 (OLS)	0.7589
N	948

[a]Value under parameter estimates are t-values
*Denotes significance at p < 0.1
**Denotes significance at p < 0.05
***Denotes p <0.01

The town and county data demonstrate better results in comparison to the state-only model. Given that the town and county sample provided greater degrees of freedom, it is not surprising that this model would reveal more significant results. All but one of the explanatory variables demonstrates a high level of significance, and the coefficients for the most part reveal intuitive results. Contrary to the state results, these community-level data show that, while land type certainly has a significant effect on WTP values, community demographics and indicators of change also have important effects.

Communities demonstrate preference for preserving larger parcels; possibly reflecting the desire to keep rural lands within their own respective communities rather than supporting external programs. Along these lines, the *IHSarea* variable, with a negative and significant impact on WTP, shows that the larger the jurisdictions the less people are willing to pay to support preservation programs. This outcome was also noted in the full model regression where WTP estimates were highest for towns and local communities and smallest for large states.

The aspect of survey implementation method also has a contributing factor on outcomes. The use of the in-person survey method has a high and negative impact on values, suggesting that in-person respondents are less likely to support a proposed policy. Whether this indicates preference toward the individual distributing surveys or impeded responses as a confrontational factor, the information is unclear. Nevertheless, there is significant indication that methodology plays an important role in determining WTP. A final striking result emerges from this community-level model. The full meta-regression model did not reveal any significant impact of the percent of existing preservation in each jurisdiction on the changes in WTP values. Yet, as we consider the community perspective on preserving rural heritage and the community value of maintaining a perceived quality of life, we expect that the activeness of preservation would impact people's perceptions. If a community maintains a large percentage of lands in some preservation program, the residents are consequently more aware of the impacts of these policies. From the community-level data, the model results reveal that, indeed, there is evidence of positive feedback from well-established preservation programs on willingness to continue support. The demonstration of successful programs appears to motivate additional support in local areas.

d) Community-level Benefit Transfers

In-sample benefit transfer methods suggest that split sample models for benefit function development may not necessarily result in more accurate transfer estimates. These transfer estimate methods generally produce errors within feasible policy ranges. However, there is no conclusive evidence that, for the community-level, a full or split-sample transfer performs better. Tables 16 and 17 summarize the benefit transfer error comparisons across town and county-level data respectively, as estimated from the in-sample transfers. These errors were obtained in the same way as the full sample errors, with only the specified split-sample model variables included in the predictions.

TABLE 16. COMMUNITIES-ONLY MODEL: TOWN IN-SAMPLE BENEFIT TRANSFER RESULTS					
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean WTP (Split Model Predicted)	Absolute Value % Error (Full Model Mean)	Absolute Value % Error (Split Model Mean)
Woodstock, CT	$0.35	$0.37	$0.07	86.64%	80.51%
Pomfret, CT	$0.40	$0.27	$0.01	72.39%	199.18%
Brooklyn, CT	$0.49	$0.40	$0.04	37.83%	142.04%
Thompson, CT	$0.23	$0.22	$0.06	70.54%	60.38%
Smyrna, DE	$0.37	$0.33	$0.26	76.12%	64.80%
Georgetown, DE	$0.61	$0.37	$0.54	116.33%	21.57%
Preston, CT	$0.44	$0.56	$0.13	20.96%	95.42%
Mansfield, CT	$0.69	$0.61	$0.29	66.22%	63.50%

TABLE 17. COMMUNITIES-ONLY MODE: COUNTY IN-SAMPLE BENEFIT TRANSFER RESULTS					
JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean WTP (Split Model Predicted)	Absolute Value % Error (Full Model Mean)	Absolute Value % Error (Split Model Mean)
Kent County, DE	$0.02	-$0.06	-$0.02	10,585.16%	5321.34%%
Sussex County, DE	$0.01	-$0.05	$0.16	902.77%	1973.20%
New Castle County, DE	$0.02	$0.04	$0.01	949.84%	519.01%

Cross-validation results for individual communities continue to validate patterns in transferability. These results are presented in Tables 18 and 19. Broadly comparing state versus town and county level results, we see a trend of worsening transferability as the jurisdiction size increases. States, overall, produce among the highest transfer errors, whereas local communities demonstrate the most accurate predictions of welfare values. For county-level data, the results are mixed. Large counties reveal poor estimates of WTP, with transfer errors between 1973% and 5321%. The smaller county, New Castle, reveals slightly better transfer performance, although these transfer errors continue to exceed local estimates by 300% or more.

TABLE 18. COMMUNITIES-ONLY MODEL CROSS-VALIDATION: TOWN BENEFIT TRANSFER RESULTS

JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean WTP (Split Model Predicted)	Absolute Value % Error (Full Model Mean)	Absolute Value % Error (Split Model Mean)
Woodstock, CT	$0.35	$0.38	0.3207	83.33%	62.12%
Pomfret, CT	$0.40	$0.41	0.4681	33.06%	54.45%
Brooklyn, CT	$0.49	$0.29	0.2901	72.84%	78.37%
Thompson, CT	$0.23	$0.24	0.2533	74.69%	48.46%
Smyrna, DE	$0.37	$0.37	0.3754	76.93%	81.45%
Georgetown, DE	$0.61	$0.56	$0.5547	20.02%	24.33%
Preston, CT	$0.44	$0.40	0.4405	94.94%	89.50%
Mansfield, CT	$0.69	$0.61	0.5751	53.90%	49.38%

TABLE 19. COMMUNITY MODEL CROSS-VALIDATION: COUNTY BENEFIT TRANSFER RESULTS

JURISDICTION	Mean WTP (Actual)	Mean WTP (Full Model Predicted)	Mean WTP (Split Model Predicted)	Absolute Value % Error (Full Model Mean)	Absolute Value % Error (Split Model Mean)
Kent County, DE	$0.02	-$0.0218	-$0.0496	1478.38%	**4613.75%**
Sussex County, DE	$0.01	-$0.0185	$0.1416	405.08%	**1561.01%**
New Castle County, DE	$0.02	$0.0842	-$0.0406	598.24%	**772.47%**

Within individual towns, most transfer errors increased, indicating less transferability of public values. It is important to note, however, that the changes in transfer errors within the communities were marginal and do not affect overall results. Despite some increase in error, the range of transfer errors may still fall within policy-relevant limits for transferability. Transfer errors for local towns range from 24.33% in Georgetown, Delaware up to 89.50% in Preston, Connecticut. Considering the range from full model results, the distribution of errors is virtually unchanged.

Interestingly, the benefit transfer results for county-level jurisdictions indicate a grey area for policy implications. In both full meta-regression results and comparative split-sample estimates, counties demonstrate moderate to poor transferability. While in the split-sample model transfer errors increased to a range of 772 to 4614 percent, the implications for benefit transfers in moderately-sized jurisdictions remain the same. Similar to state value transfers, the larger counties reveal higher average transfer errors. Therefore, while the full model suggested transfer errors due to heterogeneous study site characteristics, these split-model results suggest there are additional contributions to significant transfer errors that are not captured by jurisdictional characteristics alone.

3.2. Discussion of Findings and Final Comparisons

Implications of the split-sample models for transfer error are mixed. Compared to results from the full model, split sample transfer errors are reduced for all state jurisdictions, and in some cases by large margins. For example, mean absolute value transfer errors in Connecticut for the cross-validation transfer drop to between 70.45% and 125.84%, from full sample values greater than 1800%. In other cases state scale transfer errors remain large, but are nonetheless reduced greatly from full sample model levels. That is, for state scale benefit transfers, transfer errors are improved when the metadata are limited to state scale study sites. Nevertheless, it is also important to note that despite these improvements, transfer errors for states often remain high compared to prior findings in the literature with WTP values that are of comparable magnitude (Rosenberger and Stanley 2006). Results of the split-sample MRM are mixed for community scale transfers, with transfer errors reduced in four out of eight cases. County-scale transfer errors, however, universally increase in the split-sample model.

The poor state results may be indicative of several potential problems. Among these potential issues are the low degrees of freedom inherent in this sample. With so few study sites assessing statewide welfare values, it is likely that there are not enough observations to test and assess the systematic variations within the dataset. Having limited the number of explanatory variables included in the split-sample model, it is also possible, that these comparative results do not capture true transfer results. Similarly, the minimal sample set also prevents us from excluding additional observations or determining potential outliers. The Bergstrom et al. (2002) study, for example, contributes WTP values of very low magnitude – making predictions especially difficult. These values, ranging from average values $0.00002 to $0.003, are so small in comparison to the overall predicted values that precision in the benefit transfer estimates is especially elusive. A seemingly “acceptable” policy error of half a cent may actually result in transfer errors of over 1000% for these studies.

Finally, comparison between transfer estimation methods, the out-of-sample type cross-validation approach appears to improve transferability of values. These results are consistent with the findings discussed by Johnston and Duke (2008), whose results suggest that the method of transfer can have significant impacts on transfer errors. Particularly for state-level data, in which error estimates remained substantially high, applications of a repeated sampling technique to benefit estimation appears to improve transfer errors by at least one order of magnitude. These results are especially promising for these state data, as other results implied little support for state-level transfers.

Despite acknowledged requirements that metadata satisfy commodity and welfare consistency in tandem (Bergstrom and Taylor 2006), comparison of split-sample and full model transfer errors indicates that increased homogeneity within the metadata will not necessarily improve transfer errors. As a result, analysts may wish to exercise caution when omitting observations or splitting samples in order to impose greater homogeneity in metadata observations. In addition to risking a magnification of selection biases (Rosenberger and Johnston 2007), such practices may diminish transfer performance in some cases. Moreover, results provide minimal evidence that value surface insights are enhanced within the split-sample models.

Aside from exogenous contributors to transfer errors, it is also important to look into possible endogenous factors within the sample. By regressing the in-sample absolute value trimmed transfer errors on all explanatory variables from each of the three main models, we can identify potential variables that have significant contributions to overall error magnitude. Significant results indicate sources of bias within the metadata; as these variables consistently skew benefit function estimates. This additional knowledge is especially valuable to future choice experiment studies and policy applications. By providing additional evidence of the source of biases in transfer estimates, we can also determine if the biases are mainly methodological, researcher-based, or some less conventional source of bias. This information also guides future studies by identifying key areas in which the researcher must strive to minimize impacts. Unlike meta-analysis that strives to highlight sources of variation in public values and provide public transfer estimates, these additional investigations into benefit transfer errors shed light on indicators that can contribute to poor policy transfer results.

Table 20 summarizes the regression results and identifies significant contributors to transfer errors from each model. Each model reports only a few significant variables explaining variations in error results; a characteristic that positively suggests that most of the variables in the model perform well in benefit transfer estimation. In the full unweighted model, major contributors to high transfer errors were land type characteristics for idle and livestock production, as well as moderate parcel sizes from 1000 to 10,000 acres. These characteristics were shown to have a significant impact on public preferences across the jurisdictions and may likely contribute to transfer errors because different communities value different land types. For example, New England residents have historically supported dairy farms more than any other type of farming. These divergences may, therefore, support the need to consider several factors such as region and jurisdiction characteristics in addition to simply resource attributes in estimating welfare values.

A meta-regression analysis that assesses values across all available regions may not capture these nuances of community-level heritage and preference. We see this trend carry into the state-only model, where cross-regional sites are still included in one sample. Again, northeastern states may have very divergent preferences from southern and Midwestern states; indicating that it may be more appropriate to compare across adjacent or region-specific states when estimating public benefits. At the community-level, however, land types do not contribute significant transfer errors. These results may suggest that, while different communities have difference preferences for types of land use, the overall range of WTP values are comparable across all sites.

Of all the explanatory variables, two methodological variables demonstrate the highest magnitude contributions to transfer errors: *mlogit* and *method_person*. At the community-level, survey implementation in person contributes significant variations in WTP values – as our previous meta-regression results indicate. This survey method, therefore, has a tremendous impact on the accuracy of subsequent benefit estimates. Policymakers should consider the source of survey results prior to considering welfare estimates.

In the full and state-only models, the methodological bias of welfare estimation is particularly evident. The variable *mlogit* is the single most significant contributor to large magnitude variations in transfer estimates, and therefore, resulting errors. This result, again, suggests that policymakers must be especially cautious of methodological differences when comparing welfare estimates across study sites. In particular, when considering the overall advantages of applying meta-regression analysis to inform benefit transfer decisions, it may be advisable to consider metadata that are drawn from studies with near-homogenous methodological approaches in addition to other selection criteria discussed in earlier sections.

TABLE 20. MAJOR CONTRIBUTORS TO TRANSFER ERRORS

Variable	Full Model *(Unweighted)*	State-only Model	Community-level Model
Intercept	-1432.218 (-1.49)[a]	4729.502 (0.13)	35.602 (0.61)
Acres_1000	--	--	-19.400 (-1.55)
Acres_1to10k	-4581.665** (-1.99)	-12879.30 (-0.77)	--
Acres_10kplus	984.477 (1.42)	--	--
IHSarea	19.473 (1.05)	--	1.347 (0.68)
Prime	704.244 (0.60)	955.443 (0.34)	--
Lvstck	-230.054** (-2.53)	-1149.734** (-2.14)	-2.103 (-0.41)
Forest	-34.106* (-1.89)	-98.117 (-1.40)	-3.987 (-0.94)
Idle	328.264*** (2.58)	1456.032** (2.16)	1.119 (0.15)
Unspec_multi	-428.863 (-1.44)	-1008.187 (-0.90)	-181.625** (-1.97)
Trust_pur	-25.262 (-0.99)	-86.317 (-0.65)	1.862 (1.14)
Trust_con	-26.964 (-1.06)	-88.764 (-0.67)	0.921 (0.69)
S_t_pur	23.360 (0.95)	45.149 (0.31)	1.285 (0.97)
S_t_con	73.903 (0.98)	481.644 (0.89)	0.980 (0.84)
H_risk	-30.890 (-1.17)	-220.371 (-1.22)	-6.781* (-1.79)
No_access	75.246 (1.40)	406.203 (1.23)	2.235* (1.72)
Moderate_access	7.573 (0.50)	-40.847 (-0.38)	-0.292 (-0.42)
Inc_pop	0.0023 (0.51)	-0.1127 (0.905)	-0.000525 (-0.78)
Edu	2.036 (0.48)	--	--
Urban	-842.515 (-0.65)	-2050.061 (-0.64)	--
Response_rate	-8.830 (-0.74)	--	--
Density_hh	-0.490 (0.94)	--	--
Growth_pop	-3.170 (-0.94)	2.974 (0.08)	-0.553** (-1.96)
Percent_preserved	7.875 (0.83)	-54.018 (-0.15)	0.377 (1.34)
Method_person	658.153	--	184.068**

	(1.23)		(1.97)
Region_south	-190.967 (-1.08)	--	--
Mlogit	4504.976** (1.96)	14675.79*** (2.56)	--
Year	129.419 (1.41)	--	--
N	1580	632	948
R^2	0.1571	0.2099	0.1351

[a]Value under parameter estimates are t-values
*Denotes significance at $p < 0.1$
**Denotes significance at $p < 0.05$
***Denotes $p < 0.01$

V. Discussion and Conclusion

This thesis illustrates the first statistical meta-analysis of WTP for farmland preservation. Data are drawn from choice experiments allowing estimation of WTP per acre for multi-attribute farmland preservation in various states and at different jurisdictional scales. The model also illustrates the first use of the inverse hyperbolic sine (IHS) functional form for meta-analysis within the valuation literature. Results demonstrate the capacity of MRMs to both characterize value surfaces associated with farmland preservation and generate reduced form models for benefit transfer. The model is designed to both provide insight into the potential use of MRMs to inform farmland preservation policy and provide a formal assessment of benefit transfer performance. For the latter assessments, performance is evaluated through both various in-sample transfer approaches, as well as repeated leave-one-out, cross-validation (out of sample) tests of transfer error – a more rigorous approach than is typically applied by the benefit transfer literature.

The analysis offers a range of findings of potential relevance to welfare analysis. Results suggest the presence of a meta-valuation function that can be used as a conceptual foundation for benefit transfer of farmland preservation values, and provide numerous insights into the associated value surface. Assessments of underlying WTP measures suggest validity in estimated values across observations. Benefit transfer performance, however, is inconclusive. Comparative results for state and community scale transfers data suggest that transfer errors are dependent on jurisdictional scale, with community scale transfer errors substantially smaller than comparable state scale errors. Despite limited observations from the small state sample, the meta-regression investigation provides some feedback on future benefit transfer procedures. Furthermore, while the magnitude of transfer errors for community scale observations suggests the possibility for policy applications in cases where broad welfare guidance is desired, the magnitude of state scale transfer errors would likely preclude applied policy uses. Models splitting the metadata by jurisdictional scale do not offer unambiguous improvements in transfer performance over that found in the full sample MRM.

Evaluation of the validity of benefit transfer within this dataset, however, suggests that methodological and jurisdictional attributes significantly increase transfer errors. These findings imply that regional pooling – or pooling across different jurisdiction sizes – can degrade the validity of benefit transfers. Attempting to mitigate poor transferability of WTP values, subsequent models evaluate state and community-level data separately

Overall, model results are promising with regard to the ability of MRMs to identify components of systematic variation of WTP values and reveal patterns unapparent from stated preference models considered in isolation. Nevertheless, potential transfer errors in some cases may exceed acceptable limits. The results of this study indicate that meta-regression benefit function approaches can provide important information to guide potential policy programs across regions; however, benefit function transfers of meta-regression results should not be used to directly provide benefit estimates in specific policy contexts.

1. Suggestions for Future work

The results of this study indicate that meta-regression benefit function approaches can provide important information to guide future policy programs, such as benefit function transfers for communities establishing land preservation policies. Additional work, however, is required to provide evidence regarding the suitability of MRMs for direct benefit transfer applications. There is substantial need for additional research in this field. Future analytic work should consider the potential impact of functional form in the

IHS transformation of WTP values. Although sufficient evidence from previous studies indicates suitable performance of this transformation, future investigations may reveal additional, improved applications for this method. Similarly, comparative analysis on the performance of IHS transformations and other transformations may reveal additional support for the use of this particular transformation method. Furthermore, there is much need for improved analysis of meta-analytical applications to benefit transfer. Limited study sites are characteristic of natural resources around which many preservation policies are defined. Sophisticated methods of evaluation may help alleviate some issues associated with limited survey data and transferability procedures.

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