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Phosphorus forms and availability in organically managed grasslands

Saraswati Poudel Acharya

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AN EXAMINATION OF HOUSEHOLDS' WILLINGNESS-TO-PAY FOR WETLANDS
BIODIVERSITY CONSERVATION IN THE UNITED STATES: A BENEFIT TRANSFER
APPROACH

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Dissertation Submitted to the Davis College of Agriculture, Natural Resources and Design
at West Virginia University

in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
in
Forest Resource Science

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ABSTRACT

An Examination of Households' Willingness-to-pay for Wetlands Biodiversity Conservation in the United States: A Benefit Transfer Approach

Rajendra Prasad Poudel

This research paper provides a benefit transfer model of willingness-to-pay (WTP) for wetlands' biodiversity conservation in the United States. The validity of the estimated wetland's willingness-to-pay values is also examined. While valuation of the services provided by wetlands may be challenging due to their non-market nature, estimation of values is important. Conducting a primary study is the best option for precise results. However, researchers may recommend the benefit transfer approach in wetland valuation when there are limited time, budgetary constraints, and administrative urgency.

The benefit transfer approach involves transferring of value estimates from study sites (where research was already undertaken) to policy sites (where values are to be applied). This study extends and provides improvements to wetlands valuation literature by using information obtained from 21 study sites – 19 natural wetlands and 2 constructed or human made wetlands to estimate the values of wetlands for biodiversity conservation on six policy sites – 5 natural wetlands and 1 constructed wetland. Suitable meta-regression models have been developed to explain the values of biodiversity service provided by natural and constructed wetlands in the contiguous United States.

Meta-regression results are reported for eight models out of which models 7 and 8 are analyzed and compared for validity. In doing so, forty out of forty two observations in model 7 and thirty nine out of forty one observations in model 8 have underestimated WTP values as compared to the author reported WTP values at the study sites. The WTP values for policy sites ranged from \$0.82 (Henderson Slough) to \$29.69 (human-made wetland) in model 7 and from \$1.63 (Henderson Slough) to \$66.47 (Mobile Delta/Fahkatchee) in model 8. Policy site WTP values were adjusted with average transfer errors. Adjusted WTP is being done in response to the failure of validity test #4 and the predominance of WTP underestimation on the study sites. The adjusted WTP ranged from \$4.02 (Henderson Slough) to \$145.04 (human-made wetland) in model 7 and from \$12.17 (Henderson Slough) to \$496.07 (Mobile Delta/Fahkatchee) in model 8.

The results of validity test #1 shows an average transfer error that is lower in model 7 (average TE=79.53%) compared to model 8 (average TE=86.60%), which indicates that model 7 is slightly better. Validity test # 2 indicates that the difference between the original and estimated WTP is not different from zero in both models ($p=0.243$ for 7 and $p=0.242$ for 8). Therefore, WTP estimates obtained from these models are acceptable. The validity test of functional relationship (validity test # 3) between the original and estimated WTP in model 7 ($F_{2,39}=1.624$) and model 8 ($F_{2,38}=1.243$) indicates that WTP amounts converge to each other. Therefore, this test shows that WTP estimates are acceptable for both models. Correlation (validity test # 4) between original and estimated WTP in model 7 (0.00) and model 8 (0.14) indicates that the WTP amounts are not correlated or they have weak relationship, which rejects the validity for both models.

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DEDICATION

These efforts are fully dedicated to my parents and family members who were supportive in my academic pursuit.

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LIST OF ABBREVIATIONS

BT	Benefit Transfer
CVM	Contingent Valuation Method
CA	California
CWA	Clean Water Act (USA)
ERS	Economic Research Service (USA)
MABT	Meta-analysis Benefit Transfer
MN/SD	Minnesota/South Dakota
NOAA	National Oceanic & Atmospheric Administration (USA)
OTA	Office of Technological Assistance (USA)
RC	Replacement Cost
TE	Transfer Error
USFWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
WTA	Willingness-to-accept
WTP	Willingness-to-pay

CHAPTER ONE

INTRODUCTION

1.1. Background of Study

Wetlands are highly productive ecosystems that provide numerous goods and services (Ramsar International Bureau, 2014). They are known as the kidneys of the landscape, based on the functions they perform in the hydrological-chemical cycles, and as biological supermarkets for their giant food webs and rich biodiversity (Barbier et al., 1997). They provide many ecosystem services to other living beings and human beings (Woodward & Wui, 2001). Wetlands are characterized as public goods (i.e., nonrival and nonexcludable in that individuals cannot be effectively excluded from use of the good and where use by one individual does not reduce availability to others) and have poorly defined property rights (Ghermandi et al., 2008). Therefore, many wetland values tend to be overlooked. This might lead to unfair distribution of resources and jeopardizes the conservation efforts of wetlands that are under threat. In the United States, the loss of wetlands between 1780 and 1980 is reported at 53% in the mainland, a fraction of 1% in Alaska, and 12% in Hawaii (Dahl, 1990). However, from 1980s till 2014, the loss of wetlands has been declining, which can be attributed to the “no net loss of wetland” policy of the United States, section 404 of Clean Water Act 1972, public awareness in social media, television, and radio (USGS, 2014). Although the trend of wetland loss is declining, there are still anthropogenic threats to fragile but valuable wetlands (USGS, 2014).

Wetland value is based on the ecological services they provide. In terms of economic value that wetlands possess, the US Fish and Wildlife Service reported that anglers and hunters contributed \$38.3 billion in US economy (Allen et al., 2012). The report also found that hunters and wildlife enthusiasts spend billions of dollars each year on travel expenses and equipment

associated with wetland habitats. Because of the numerous benefits produced by wetlands to the general public, federal and state governments provide incentives, regulate, and manage wetland resources to protect the resources from degradation and destruction.

The Federal Government protects wetlands directly and indirectly through regulations, incentives and disincentives (Votteler & Muir, 1996). The US legislation has given authority to the US Army Corps of Engineers, US EPA, US Fish and Wildlife Service, National Oceanic and Atmospheric Administration and Natural Resource Conservation Service to regulate and manage the country's wetlands (Dahl & Allord, 1997). Policymakers came up with a wetland policy, which is called "No Net Loss" policy. This policy is aimed at maintaining the national wetlands. One of the provisions of this policy is compensation for loss of wetlands. That is, every acre of wetland destroyed, must be compensated for by at least an equal amount of acres as well as productivity. This means that wetland losses must be offset by wetland gains in terms of actual acreage and, to the extent possible, ecosystem function (Votteler & Muir, 1996). To achieve the objective of no net loss, the Federal Government utilizes several different environmental regulations such as section 404 of the Clean Water Act at the federal level and section 401 at the state level, which legally protect wetlands, provide rules and regulations for citizens and corporations interacting with wetlands, and incentives for the conservation of wetlands (Dahl & Allord, 1997).

Since mid-1980s, the growing application of environmental valuation tools hinges on two factors: the growing use of cost-benefit analysis as an important decision-making tool in environmental policy, and the growth of benefit transfer application as an important screening tool for non-market environmental valuation. Government planners and experts may often want to use benefit transfer technique since they are often constrained by expediency, resources, and administrative hurdles (Shrestha & Loomis, 2001). In practice, conducting primary research in the

everyday policy process would not be efficient and many primary studies would be of limited scope, and low quality (Boyle & Bergstrom, 1992; Shrestha & Loomis, 2001).

Due to the difficulty associated with valuation using primary data, researchers have developed a quick, cheap, and reliable valuation method using meta-analysis, which is commonly known as benefit transfer. This approach is useful when there is a limited amount of time and budget as well as administrative urgency. Since its inception, this approach has grown rapidly in several research disciplines. Different authors have defined benefit transfer in different ways. The common definition is the use of existing (available) benefit estimates to a site or population with similar attributes (to be undertaken) compared with the original study that generated the benefit estimates (Desvousges et al., 1992; Brookshire & Neill, 1992; Smith, 1992; Bergstrom & Boyle, 1992).

Benefit transfer is a process of transferring value estimates from a study site (where research was undertaken) to a policy site (where research is to be undertaken or sought) where sites may vary geospatially and temporally. This is done by transferring (i.e., forecasting) benefit estimates on the basis of benefit transfer functions estimated from data collected at other similar sites (i.e., study sites) to other sites for which site data on benefits are unavailable (i.e., policy sites). Benefit transfer techniques include fixed value transfer, expert opinion, and value estimator models (Bergstrom & DeCivita, 1999). Fixed value or point transfer ignores any benefit functions and therefore only value(s) are transferred without any site correspondence or site similarity. Expert opinion is limited in some literature and is now outdated in practice and is based on researcher's judgment in transferring benefits. Value estimator model is synonymously known as benefit function transfer and was used to calculate willingness-to-pay (WTP) at policy sites as well as to compute WTP in study sites for validity tests in this study. Although benefit transfer

techniques are subject to a number of conceptual and empirical limitations, these techniques are widely applied by government agencies as input into economic assessments of public policies and projects.

1.2. Problem Statement

Wetlands are public goods and they produce non-market benefits, which can make valuation challenging. Thus, wetlands continue to be under significant threat from destruction and economically underestimated. If the general public does not know how much wetlands are worth or how much value the wetland services provide, they will not know the trade-off of wetland loss or destruction and therefore they cannot make sound economic decisions regarding protecting wetlands. Once the public becomes aware of wetland resources and their associated values, they will become aware of what they are losing in monetary terms. They will also become aware of the impact of wetland loss on their life support system (e.g., land, water, and/or vegetation). Until now, there is not much information about monetary values that wetland provide. Thus, the general public typically lacks knowledge about the value of wetlands. The deterioration of wetlands will continue until the social, cultural, ecological, and economic values of these wetlands are known. Benefit transfer research could be a potential source to fill that gap. Thus, this research attempts to value selected wetlands in the contiguous United States.

Due to limited availability of funds to collect primary data for the valuation process, the benefit transfer valuation method was used in this research. Specifically, the meta-analysis and benefit transfer protocol suggested by Bergstrom & Taylor (2006) was adopted in estimating the values of policy site wetlands. The study sites were selected from valuation literature using meta-analysis whereas policy sites were selected on the basis of their economic and ecological importance and whether they warrant conservation efforts soon. Thus, the policy sites selected

are those wetlands that are under anthropogenic pressure from intensified urban sprawl, agricultural production, and infrastructure development near or in the wetland area.

1.3. Objectives

The overall objective of this research is to estimate household's willingness-to-pay for biodiversity conservation in the United States. The specific objectives of this study were to: (1) develop a benefit transfer model for inland wetland's biodiversity conservation in the United States; (2) estimate wetland conservation value of five natural wetlands and one man-made wetland in the United States, and (3) examine the validity of benefit function transfer for valuing inland wetlands in the United States. This study is divided into seven chapters. Chapter II provides an overall literature review. Chapter III presents the theoretical model used in the study. Chapters IV and V cover the methods and results, respectively. Chapter VI covers the discussion of results. Lastly, the overall summary and conclusions are presented in Chapter VII.

CHAPTER TWO

REVIEW OF LITERATURE

2.1. Wetlands

Wetlands in the United States are defined in two ways: (1) regulatory definition and (2) scientific definition.

(1) Regulatory definition

The Clean Water Act (CWA) defines wetlands as those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas (Environmental Protection Agency, 2014).

(2) Scientific definition

The US Fish & Wildlife Service defines wetland as “lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of classification wetlands must have at least one or more of the following attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year” (Cowardin et al., 1979). This definition is widely accepted all over the world.

Wetland types

Inland wetland: These wetlands (nontidal) are characterized by dominating herbaceous plants and frequently occur in poorly drained depressions, floodplains, and shallow water areas along the edges of lakes and rivers. Inland wetlands include freshwater marshes, prairie potholes, swamp

marshes, and lacustrine. In the United States, examples of famous inland wetlands are the Great Lakes coastal wetlands, the prairie pothole region, and the Florida Everglades. Freshwater marshes are characterized by periodic or permanent low level of water, emergent vegetation, little or absence of peat deposition, and mineral soil. These wetlands receive water from surface flow, including floodwater and runoff. Prairie potholes are small pockmarks developed after glacial till remnants and rain filled the holes found in Prairie region. Swamps primarily receive water from surface runoff and are dominated by trees and shrubs. These wetlands occur in either freshwater or saltwater floodplains. These types of wetlands are characterized by wet soils during the growing period and stagnant water during some months of the year. A well-known example of a swamp wetland is Virginia's Great Dismal Swamp. Lacustrine lakeshore wetlands are wetlands found in topographic depressions with low vegetation covers. These lacustrine wetlands have more than 8 hectares, mostly lacking vegetation, and may be tidal or nontidal (Northern Prairie Wildlife Research Center/USGS, 2014).

Coastal wetland: These wetlands (tidal) occur along coastlines and are influenced by freshwater from runoff, rivers, or ground water. Tidal marshes are commonly known as salt marshes and are characterized by salt-tolerant plants such as saltgrass (*Spartina patens*) and glasswort (*Salicornia virginica*). These marshes are considered as the most productive as they receive inflow of nutrients and organics from surface and/or tidal water. Tidal freshwater marshes are generally located upstream of estuaries. The water is fresh and lacks significant salt amount, which allows for a greater diversity of plants. The most common plants in these marshes are cattail (*Typha species*), and arrowhead (*Sagittaria graminea*) that support and provide refuge for macro-invertebrates, bird and fish species. (These wetland classifications were adapted from Office of Wetlands, Oceans and Watersheds, EPA, 2001 except lacustrine wetland).

In addition to the above wetland types, other classification systems are used. For example, Cowardin et al. (1979) suggested a scientific classification for wetlands but has been ignored in wetland valuation literature. These include: (1) Marine, (2) Estuarine, (3) Lacustrine, (4) Riverine, and (5) Palustrine. The descriptions of these different wetland types are presented below (USGS, 2014):

(1) Marine deepwater

This deep water habitat is Open Ocean overlying the continental shelf and its associated high-energy coastline. Salinity in marine ecosystem exceeds 30 parts per thousand (ppt) with little or no dilution where the mouth of estuaries is not present.

(2) Estuarine wetland

This type of deepwater tidal habitats and adjacent tidal wetlands are usually semi-enclosed by land but have open, partly blocked or patchy access to the open ocean, and in which ocean water is at least occasionally diluted by freshwater runoff from the surrounding land. The salinity in this type of wetland is less than 30 ppt. It is divided into sub tidal (continuously submerged) and intertidal (exposed and flooded by tides).

(3) Riverine wetland

This type of wetland is contained within a channel with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 ppt. A channel is an open way where water flows through or which forms a connecting link between two bodies of standing water (Langbein & Iseri, 1960). This wetland is subdivided into tidal, lower perennial, upper perennial, and intermittent wetland.

(4) Lacustrine wetland

This type of wetland consists of the following characteristics: (1) situated in a topographic depression or a dammed river channel, (2) lacked trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage of the total wetland area, (3) total area exceeds 8 ha. (20 acres), (4) the depth exceeds 2 m., and (5) may be tidal or nontidal, yet ocean derived salinity is always less than 0.5 ppt.

(5) Palustrine wetland

This wetland is characterized as nontidal dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity caused by ocean-derived salts is below 0.5 ppt. It also includes wetlands lacking such vegetation but with all of the following characteristics: (1) area less than 8 ha. (20 acres), (2) absence of active wave-formed or bedrock shoreline features, (3) water depth less than 2 m, and (4) salinity due to ocean-derived salts less than 0.5 ppt. This wetland has the following classes- Rock Bottom, Unconsolidated Bottom, Aquatic Bed, Unconsolidated Shore, Moss-Lichen Wetland, Emergent Wetland, Scrub-Shrub Wetland, and Forested Wetland.

Wetland functions and values

Wetland functions may be defined as a process (or a series of processes) that take place in a wetland system. The wetland function needs to be redefined since many wetland literatures have not included off-site natural resources and structure as part of its definition (Kusler, 2004). Off-site natural resources include biota and edaphic components that are available nearby the site being taken into analysis. The structure part includes soil and life forms such as landscape, water, and/or vegetation. Thus, inclusion of both off-site natural resources and structure provides a meaningful definition of wetland function.

The term ‘value’ may be defined in various contexts. Ecologists define value as the environmental goods and services have in their own right, and which is not derived from extrinsic attributes (Freeman, 2003). Economists define value as a fair or proper equivalent in money and commodities. The term equivalent in money means the sum of money that would have equivalent welfare effects of individuals derived from the value (Freeman, 2003). Welfare is derived from the consumption of economic goods of services by an individual or consumer. In short, wetland values are properties that are considered valuable to human beings. The value of a wetland lies in the benefits that it provides to the environment or to the human beings. The literatures in wetland research have little discussion distinguishing wetland functions and values.

The above relationship or connection shows that researchers attach values to wetlands by considering both their ecological functions and services. DeGroot et al., 2002 and 2012 estimated multiple ecosystem services at global context. This connections are described in table 1 and figure 1 below. Table 1 shows the connections among the different functions, services, and values attached to wetlands. The major wetland functions are physical/hydrological, chemical, biodiversity, and natural with their goods/services provided to human beings valued in monetary terms. The interrelatedness among the wetland functions, services, and values is described in many wetland valuation literature (e.g., Costanza et al., 1997).

Table 1. Major wetland functions, economic goods and services, and types of values.

Wetland functions	Goods & services	Wetland values
<i>Physical/hydrological functions</i>		
1. Flood control	Protective natural sponge by capturing, storing and slowly releasing flood	Cost to replace natural flood control in Minnesota is \$1.5 million/year (Fausold & Lilieholm, 1996). Current use value.
2. Coastal protection	Storm buffer reducing erosion and wave in coastal marshes, & mangrove swamps	Needs significant amount of investment to replace coastal marshes. Current and future use values.
3. Ground water recharge	Increased water supply to living beings	Clean drinking water project through long pipelines costs immensely. Current use and non-use preservation values.
4. Sediment retention	Prevention of loss of soil by wind, runoff, or other removal processes	High cost to replace by dams. Current and future use values.
5. Atmospheric equilibrium	Carbon sequestration, micro-climate stabilization, and reduces greenhouse gas	Reduces global warming by storing carbons, substantial amount to replace this service. Current and future use values.
6. Soil formation	Weathering of rock and the accumulation of organic material	Hardly available literature, values unknown/cannot be estimated. N/A values.
<i>Chemical functions</i>		
1. Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess nutrients and compounds	High cost to replace by constructing wetlands. In supply water, human-made wetlands are increasing. Current and future use values.
2. Pollution interception	Filtering function to remove or reduce pollution	Save a great deal of money. In GA, a 2500 acres wetland saves \$1 million annually (OTA, 1993). Future use value.
3. Water quality control	Improved water quality, reduces costs of water purification	Save high cost that needs to establish water purification plant for use. Future use value.
<i>Biodiversity functions</i>		
1. Habitat and breeding ground	Habitat for resident and transient populations	Investment in habitat is very expensive. Current use value, existence value.

2. Genetic resources	Medicine, genes for resistance to plant pathogens and crop pests, ornamental species	Sources of unique biological materials and Products demand high cost.
<i>Natural functions</i>		
1. Recreational activity	Eco-tourism, sport fishing, and other outdoor recreational activities	Provides opportunities for recreation e.g., tourism. Current use value.
2. Cultural heritage	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems	Provides opportunities for non-commercial uses. Existence value, philanthropic value.
3. Food production	Produces food for consumption such as rice, fruits and meat	Production of fish, game, crops, nuts, and fruits.
4. Raw materials	Timber, firewood, fodder, medicinal plants and so forth.	The production of lumber and fuel. Current use value

To illustrate the relationship among functions, services, and values of wetland, Turner et al. (2000) has given the following example (see figure 1) where the total economic value of wetland is not equal to the total value of wetland. The reason is that wetland provides not only the economic values of benefits but also provides nonuse values and existence values, which are derived from the satisfaction of knowing the wetland will continue to exist (Turner et al., 2000). Nonuse and existence values have also economic values, which Turner et al. (2000) have not taken into consideration.

Figure 1. Connections among Wetland Functions, Uses and Values (Turner et al., 2000)

2.2. Wetland Valuation Methodologies

The economic value of wetland resources is equal to the benefits that these systems offer to human beings (Freeman, 1993; Woodward & Wui, 2001). Several valuation methodologies are used to obtain estimates in natural resources research including wetlands. The most common methods are net factor income, replacement cost, hedonic pricing, contingent valuation method, and benefit transfer. The net factor income (NFI) method is ideal when a wetland provides service that leads to an increase in producer surplus (production function). In this method the physical relationship between wetland area and the underlying economic activity is estimated. It is then possible to find the change in producer surplus associated with the wetland's area taken into account. In net factor income, researchers often assume that demand of goods and services provided by natural resources is perfectly elastic. For simplicity, the NFI assumes perfectly elastic demand so that the impacts of the wetland on consumer surplus can be ignored in analysis (Woodward & Wui, 2001).

The producer surplus that is generated by a wetland can also be estimated using the replacement cost (RC). This approach estimates values of wetland services based on the price of the cheapest alternative way of obtaining that service. For instance, the value of a constructed wetland in wastewater treatment might be estimated using the chemical, engineering or mechanical alternatives. Shabman and Batie (1987) describes replacement cost method as valid only if the following three conditions are met: (1) Engineering system provides functions that are equivalent in quality and magnitude to the ecosystem service; (2) Engineering system adopted in place provides the lowest cost alternative to replace the ecosystem service; and (3) if the ecosystem service is no longer available, then collective effort by individuals is enough to pay the incurred costs.

The hedonic pricing is used to estimate economic values for environmental services that directly comes from market prices. It is mostly applied in determining housing prices that reflect the value of local environmental attributes such as air, water, or noise pollution and amenities such as aesthetic views. The contingent valuation method (CVM) is extensively used to estimate economic values of ecosystem and environmental services. This is the only method that can be used to estimate both use and nonuse values of ecosystem services. In this method of stated preference, respondents are asked how much they would be willing to pay for specific environmental goods or services. In some cases, respondents are asked for the amount of compensation they would be willing to accept to give up specific environmental services. Contingent valuation is one of the only ways to assign dollar values to non-use or passive use values of the environment (Woodward & Wui, 2001).

Since primary research is a time consuming and budget-oriented, researchers have developed a quick, cheap, and reliable valuation method using benefit transfer. This approach is quite beneficial when there is lack of time, little or no budget as well as administrative urgency that may cover public welfare programs. Because of its novel approach, benefit transfer has grown rapidly in several research disciplines. Benefit transfer is a process of transferring value estimates from a study site (where research was undertaken) to a policy site (where research is to be undertaken or sought) where sites may vary geospatially and temporally. This is done by transferring (i.e., forecasting) benefit estimates on the basis of benefit transfer functions estimated from data collected at other similar sites (i.e., study sites) to other sites for which site data on benefits are unavailable (i.e., policy sites).

Benefit transfer is theoretically a useful tool for policy makers to estimate the benefits of a study site, based on existing research, for substantially less time and expense than a new primary

study (Brookshire & Neill, 1992; and Desvousges et al., 1992). Benefit transfers include two general methods: value transfers and function transfers. Value transfers are the use of point estimates of value or range of point estimates of value. Function transfers necessitate the adjustment of a valuation (benefit or demand) function from a study site to the policy site. The degree of correspondence between the study site and the policy site determines the validity of a benefit transfer (Rosenberger & Phipps, 2007). In 1992, benefit transfer received special attention in a workshop co-sponsored by the Association of Environmental and Resource Economists and US Environment Protection Agency.

Meta-analysis, which is often used in benefit function transfer, is an approach for synthesizing the results of numerous studies. In other words, it is the study of metadata. This approach has widely been utilized in social science research for distilling information of economic values on environmental goods and services (Brouwer & Spaninks, 1999). This approach is beneficial for rigorous statistical synthesis of the literature that cannot be achieved using qualitative analysis where imaginative judgment of researcher is used. Based on Woodward & Wui (2001), there are two types of meta-analyses: 1) actual data from multiple studies, and 2) results of multiple studies. In valuation research, the second type of meta-analysis has been applied to interpret valuation studies. The actual data contains original data that are directly taken from primary research and results of multiple studies are data extracted as they were mentioned in previous studies directly and then adjusted based on the interest or need of researcher.

2.3. Empirical Studies on Wetland Valuation

A number of studies have been conducted to estimate values of wetlands. For example, this research examined several literatures from 1975 to 2012 that were used for study sites in the benefit transfer approach. Although wetland valuation studies have been done, methods and procedures

to compute WTP for policy sites and examination of the validity for successful transferability of WTP values are lacking. There are significant improvements in valuation such as application of meta-analysis protocol, sound economic theory and econometric tools, use of GIS in decision-making, and rich stock of literature.

There are three major articles in wetland valuation literature that made significant contribution in developing empirical models as well as theoretical framework to value wetlands.

- Moeltner and Woodward (2007) examined two policy site wetlands -Swamp Cedar and Shoshone Ponds Natural Area in Spring Valley, NV using a total of 11 study sites from the USA and one site from Canada. They used multiple regression model to estimate WTP values at policy sites but no detail was provided on how WTP values at policy sites were computed. Based on their calculation, approximately \$2 million value was estimated for habitat service per year for Nevada and Utah households.

- Brander et al. (2006) described about scaling the data, descriptive statistics, and economic intuition of income and wetland area for determining willingness-to-pay for selected wetlands. The positive and negative coefficients of income and area and their interpretation were discussed in their paper.

- Woodward and Wui (2001) included 39 valuation studies in wetland services from global coverage. This is the only set of wetland valuation studies with open access dataset. Bivariate graphs and multivariate log-linear models were analyzed in their paper. The first model they estimated accounted for physical attributes of wetland systems but ignored the wetland valuation methods. The second model included valuation methods and data/publish attributes as variables but ignored the physical attributes (i.e., it takes the opposite approach). The third model is the full model where all variables were taken into account. Interpretation of the main findings of their

models was done succinctly. For example, the impact of negative sign in wetland area in log-log models for small and large wetland area was described in detail. In addition, quality of research and wetland values per acre were discussed in bivariate graphical analysis and also in results.

In terms of wetland types, this research included coastal, freshwater, high elevation moist, lacustrine, prairie potholes, and swamp wetlands in the analysis. Louisiana marsh and the Great Lakes are two coastal wetlands included in the dataset. These wetlands have higher economic values than other wetlands. The economic value of freshwater wetlands were studied by some authors. For example, the value ranged from \$14.62/ha for the Mountain region (Moeltner & Woodward, 2007) to \$794579.12/ha for Northern Plains/Lake States (Roberts & Leitch, 1997) region. Roberts & Leitch (1997) conducted an economic valuation of flood control, public water supply, wildlife habitat, and aesthetic values in Mud Lake, which is a lacustrine wetland in Northern Plains/Lake States. Hovde and Leitch (1993) conducted valuation research in prairie potholes located in Northern Plains/Lake States. These wetlands are economically not very productive (lower WTP) as compared to freshwater wetlands but they are very important for migratory birds and resident mammals. Whitehead and Bloomquist (1991) conducted a study in swamp wetland in Appalachian region and found that these type of wetlands are also not economically highly productive compared to coastal wetlands but provide very good refuge to terrestrial and aquatic wildlife.

Wetland valuation studies have also looked at human-made wetlands. MacDonald et al. (1998) conducted a research in incremental environmental benefits in created/human-made wetlands with special reference to non-point source pollution in Little River/Rooty Creek, Georgia. This was one of the human-made wetland included in the study sites that was used in this research Mitsch (2006) presented a finding of 15-year experiment conducted in an outdoor laboratory of

Ohio State University on human made or created wetlands (not equivalent to constructed wetland) and found that created wetlands provide as many ecological services as the natural wetlands. An important note is that created wetlands and constructed wetlands are not exactly similar. Constructed wetland is designed for wastewater treatment or for water supply for human population while created or human-made wetland may be created for wildlife, wilderness, and water reservoir. The study found that the number of species colonizing in created and natural wetlands after five years is almost similar. Thus, created wetlands provide approximately the same level of ecological services as the natural wetlands. In addition, both wetlands sequester carbon for years. This conclusion may not be appealing to other researchers who believe that created wetlands may not provide the same level of ecological services as natural wetlands.

Many academic works have taken place in the past fifteen years that test the validity of alternative value transfer methods for different environmental goods. The closer the study site is to the policy site, the more likely that both the good being valued and the user population affected will be similar, and therefore the transfer errors would be lower (Rosenberger & Phipps, 2007; Bergland et al., 2002). Transfer validity tests also suggest that transfer errors are smaller if people have had experience with the environmental good in question, but the transfer errors do not seem to be lower for use than for non-use values. A review done by Ready & Navrud (2006) in cross-country benefit transfer studies found that the average transfer error for cross-country benefit transfers was in the range of 20% to 40%. However, they reported individual transfer error as high as 100% to 200%. Even fairly small transfer errors can be rejected using the classical statistical tests (usually t-tests with null hypotheses of transferred value being equal to the original value). The transferability of function transfer over unit value transfer has been questioned in two studies. Bergland et al. (1995) tested the transferability of benefit function transfer for water quality

improvements across two Norwegian rivers. In this case, the benefit function transfer was rejected. These authors reinforced socio-economic differentiation (income gap) and incorporated site quality between studies in their analysis. Similarly, Downing & Ozuna (1996) tested the transferability of benefit function transfer for saltwater fishing in Gulf of Mexico. They concluded that the procedure of utilizing the benefit function transfer to determine terms of appropriate compensation to harmed individuals at a policy site is unreliable and they concluded that the benefit function transfer is not reliable for benefit transfer.

CHAPTER THREE

ECONOMIC THEORY

3.1. Economic Theory in Wetland Valuation

Economic analysis is usually concerned with the estimation of values or welfare measures. Welfare measures are derived by asking to individuals on how much they are willing to pay for the goods or services in question. Alternatively, individuals may be asked what is the minimum amount of compensation they require if the good or service is taken away.

The concepts of willingness-to-pay (WTP) and willingness-to-accept (WTA), their underlying assumptions, importance of WTP/WTA in economics, ways of measuring WTP/WTA in environmental economics and relationship between WTP/WTA with compensation variation (CV), equivalent variation (EV), and consumer surplus (CS) are all very important in nonmarket valuation of environmental resources (Freeman, 2003).

Willingness-to-pay (WTP) is the maximum amount of income an individual would give up in order to receive the good. Willingness-to-accept (WTA) is the minimum amount of income an individual would require in order to give up a good. Alternatively, WTP is how much an individual would buy the good relevant for valuing the proposed gain of a good; WTA is how much an individual would sell the good for valuing a proposed gain to give up (Freeman, 2003).

In non-market valuation, a WTP/WTA concept has been extensively applied. These concepts have contributed to non-market valuation in the field of natural and social sciences. The concepts of WTP/WTA have affected the big picture of environmental economics. The importance of WTP/WTA concepts are increased acceptance of WTP/WTA concepts by government and private industry decision makers, WTP/WTA has inextricable relationship with non-market valuation methods, application of WTP/WTA concepts in most environmental economics policies,

and WTP/WTB elicits the individuals' preference for a proposed policy change to accept or decline. WTP/WTB concepts have been largely used for use and non-use values of ecological services. No other economic issues have been experimentally studied in rich set of goods (Horowitz & McConnell, 2003).

Environmental economists measure WTP/WTB using nonmarket valuation methods. For non-market goods and services, environmental economists generally adopt a two-step procedure. (1) meta-analysis of contingent valuation studies to determine factors explaining household willingness-to-pay (WTP) for the goods in question; and (2) benefit transfer to project mean household WTP values (KC & Collins, 2011). First, the economists gather data from existing CV research on goods or service and develop regression models to explain WTP with variables related to the CV methods, goods/services in question, and sample population characteristics. Second, they utilize benefit transfer in which coefficients are estimated for the explanatory variables to compute WTP for study sites and/or policy sites.

Willingness-to-pay (WTP) measures are widely used to provide information to policy makers regarding the economic value of nonmarket, or non-economic, environmental assets. For example WTP is used as an input into cost-benefit analyses (e.g., to determine the merit of a proposed wetland habitat improvement program) or as part of resource damage studies (e.g., to establish levels of compensation for coastal fishermen after an oil spill). The first case considers an environmental improvement or gain, for which a WTP measure is conceptually appropriate.

To elicit WTP estimates of any goods and/or services; empirical analysis coupled with economic models are utilized. The models and analyses differ depending on objectives, data, researchers' interest, and goods/services. Previous studies on non-market valuation studies have used WTP as the dependent variable (e.g., Shrestha & Loomis (2003) and Moeltner & Woodward

(2007)) in their model. The model may take any functional (e.g., form-log, linear, trans-log etc.). The choice of explanatory variables differs on a case-by-case research as the choice of these variables depends on objectives and methods. After selecting the independent variables, environmental economists compute WTP. Before running the regression equation, it is necessary to test the data (normality, heteroscedasticity, random/fixed effects, correlation, and spatial autocorrelation etc.) to avoid unexpected errors or bias in results.

Knetsch (1990) claimed that large differences between WTA and WTP may have other compelling effects on environmental policy. These occur when the appropriate welfare measure is willingness to accept (in most instances, environmental quality can only deteriorate) but policy analysts use willingness to pay as the measure of benefits.

In order to elucidate the symmetrical relationship between WTP and WTA with compensation variation (CV), equivalent variation (EV), and consumer surplus (CS), a simple graph (see figure 2) which is originally developed by Bates (undated) has been presented below. When describing symmetrical relationship between WTP/WTA with CV/EV, the environmental economist should consider two cases brought by price (i.e., price decrease and price increase). In the case of price decrease, CV is WTP for purchasing the good at new price level. In the case of price increase, CV is WTA for preventing the reduction in utility. A similar relationship between WTP/WTA and EV exists. In the case of price decrease, EV is WTA to voluntarily forego the proposed price fall. In the case of price increase, EV is WTP allowing maximum amount that could be taken away from the individual to have equal effect due to the price change.

Figure 2 illustrates two cases. The first case is the increase in environmental quality and the second case is decrease in environmental quality. In positive (increase in quality) environmental quality, CV/WTP and EV/WTA with positive utility can be assessed. In negative

(decrease in quality) environmental quality, EV/WTa and CV/WTP with negative utility can be assessed. The compensating and equivalent variation are often considered as implied property rights and obligations associated with alternative price levels. CV measures implied property right in status quo welfare and EV measures implied property right in the changing scenario. In the case of increased utility, CV/WTP is the maximum amount that an individual is willing to pay to receive positive environmental changes. In the same curvature, EV/WTa is the minimum amount that an individual is willing to accept at no change in environmental quality. Another case that can be considered is the reduction in utility. In such case, CV/WTP is the maximum amount that an individual is willing to pay to resist the change and EV/WTa is the minimum amount that an individual is willing to accept to make the change to occur.

Figure 2. Relationship of WTP/WTa with CV/EV in environmental valuation
(John Bates, undated)

Understanding the economic intuition behind WTP/WTa in valuation makes it easy to understand ecosystem services and their associated costs and benefits. The relationship of WTP/WTa with costs and benefits of ecosystem services may be explained in terms of individual's readiness to pay for using or not using the goods or services. In the following figure published by Pearce (2007), MC_{ES} is the aggregate costs for conserving ecosystem service at certain level. The benefits of maintaining biodiversity is given by $D_{ES,CNC}$. The optimal provision of ecosystem service from economic standpoint is given by ES_{opt} .

Figure 3. Stylized ecosystem service with costs and benefits

Notation used

ES ecosystem services

ES_M ecosystem service of market or commercial services

$D_{ES,C}$ demand curve of ecosystem service of commercial services

$D_{ES,CNC}$ demand curve for commercial & non-commercial ecosystem services

ES_{min} minimum ecosystem services

MC_{ES,m} marginal cost for managing ecosystem service

MC_{ES, oc} opportunity cost of managing ecosystem services

ES_{, opt} optimal provision of ecosystem services

3.2. Meta-analysis and Benefit Transfer Protocol

Since 2000, the literature on economic valuation of goods and services has increased rapidly. However, details on theoretical protocol to conduct benefit transfer research is lacking. In 2006, Bergstrom & Taylor proposed a theoretical model and underlying data collection protocol for an acceptable theoretical procedure in meta-analysis and benefit transfer. Their proposed economic theory and data collection protocol are utilized in this paper.

Among the theoretical model suggested by Bergstrom & Taylor (2006), a “weak structural utility theoretic” (WSUT) model specifies the relationship between explanatory variables and an underlying utility function. This theoretical model represents a household or individual utility function including environmental attributes, for example, change in wetland habitat quality. Bergstrom & Taylor (2006) noted that by using on WSUT model, a researcher can estimate a WTP function empirically while maintaining the flexibility to introduce additional explanatory variables in the model, such as core economic and methodological or study design variables.

This research is particularly motivated by a WSUT indirect utility function as proposed by Bergstrom & Taylor (2006). The authors suggest the estimation of willingness-to-pay (WTP) may be represented by a conditional indirect utility function. The model is shown in equation 1.1.

$$V = V_j(P_j, M_j; Q_j, QUAL_j, SUB_j, H_j, I_j) \quad \text{-----} \quad (1.1)$$

Where, V is indirect utility function; j subscript is the individual in all independent variables; P is price; M is income; Q is quantity of nonmarket commodity available; QUAL is quality of commodity; SUB is measure of substitute available for commodity; H is income attribute of an individual, and I is measure of information available to the individual.

Assuming there is no uncertainty in demand and supply functions, then WTP for a change in quantity available from reference state I to target state (T) is represented as-

$$\Delta V = V_j(P^T_j, M_j - WTP; Q^T_j, QUAL^T_j, SUB^T_j, H_j, I_j) - V_j(P^R_j, M_j; Q^R_j, QUAL^R_j, SUB^R_j, H_j, I_j) \quad \text{-----} (1.2)$$

The general bid function (i.e., the difference between target and reference state can be obtained from equation 1.1 and 1.2.

$$WTP = f(P^T_j - P^R_j, Q^T_j - Q^R_j, QUAL^T_j - QUAL^R_j, SUB^T_j - SUB^R_j, H_j, I_j) \quad \text{-----} (1.3)$$

The empirical meta-analysis benefit transfer model should include core economic variables (price and income) as indicated in equation 1. The rest of variables in equation can vary and are subject to researcher's preference.

Adopting Bergstrom & Taylor's theoretical model

The weak structural utility theoretic (WSUT) model is more relevant in this research since it allows flexibility in adding variables. The underlying utility theoretical model have not been incorporated in this research but inclusion of this theoretical economic model that consists of core economic and study design variables help explain the WTP as a function of the variables of interest such as income, method of study, location, study period, author characteristics, and commodity that were included in this study.

An environmental economist should be aware of how his/her economic model addresses the research question. In this context, s/he may utilize standard protocol suggested by Bergstrom & Taylor (2006). S/he may follow standard research protocol when estimating meta-analysis benefit transfer model. The protocol includes (1) theoretical model development, (2) data collection procedure, and (3) data coding, analysis and interpretation. It is strictly recommended that all meta-analysis benefit transfer models should satisfy consistency in core economic variables, commodity variables, and welfare measure variables. The data collection and analysis protocol are described below.

Adopting Bergstrom & Taylor's objective and search criteria

The collection method used in this study is in line with the protocol framed by Bergstrom and Taylor (2006). First, keeping in mind the objectives and rationale of this research, appropriate wetland valuation primary studies were searched using the following sources: three existing meta-analyses focusing on the economic value of wetlands (Woodward & Wui, 2001; Borisova-Kidder, 2006; Moeltner & Woodward, 2007); the database on Environmental Valuation Reference Inventory (EVRI) Canada; Science Direct, a searchable database focusing on environmental non-market valuation studies; and a general searchable database of economic literature. The large number of natural wetland studies was reduced into 21 studies with 42 observations. Similarly, three constructed wetland study sites and one policy site were identified and selected for benefit transfer study. These literatures are mostly peer-reviewed articles which matches the recommendation of Bergstrom & Taylor (2006). During the analysis, some assumptions such as using the same monetary units (i.e., US \$ indexed 2012 year) and converting wetland area in hectares have to be done in order to bring the reported data in different units into homogenous units.

Adopting Bergstrom & Taylor's selection criteria

As suggested, the selection criteria should satisfy the commodity consistency and welfare consistency. In commodity consistency, great care must be taken in the case of wetland, since it provides broad range of ecological services. The commodity of interest should be the same (or identical) within and across studies. This research proposed biodiversity as a passive use or service, which meets commodity consistency of meta-analysis and benefit transfer protocol suggested by Bergstrom & Taylor (2006). The welfare measure consistency should be satisfied by applying the same welfare measure. In this research, willingness-to-pay is a welfare measure for the general public or societal benefit.

Adopting Bergstrom & Taylor's data coding

The selection of appropriate information from study sites and clarity on coding for consistent output is performed in data coding. The core economic and study design variables should be coded in order to make sure there is a maintained consistency in model. If one study has been conducted using contingent valuation method and replacement cost to estimate WTP, then the author should control the heterogeneity within and across studies. In this research, study design variables' heterogeneity was controlled using eight models.

Adopting Bergstrom & Taylor's empirical analysis

In empirical analysis, the analyst must be careful which functional form works best for the proposed research. For regression analysis, the log-linear, double log, linear, linear-log functional forms may be among the choices. In practice, log-linear or semi-log relationship is attractive to use since the scale of WTP estimates and independent variables differ.

The utility theoretical models (SSUT and WSUT) validity tests have been applied in previous meta-analysis benefit transfer models. The convergent validity tests in WSUT model in

outdoor recreation (e.g., Loomis & Rosenberger, 2006; Shrestha & Loomis, 2003) have shown promising results. Bergstrom & Taylor (2006) have described advantages and disadvantages of SSUT and WSUT models of underlying utility function. The advantages of strong structural utility theory (SSUT) approach is that it maintains consistency with the theoretical compensating welfare measures, consistency in collected data, produces theoretically stronger estimated models, stringent predictions compared to empirical results, and uses the specification of strict utility theoretic model. However, there are disadvantages to this approach because the functional form is not flexible, adherence to strict utility theoretic model limiting available transfer studies, little flexibility in meta-analysis and benefit transfer, imposition of individual budget constraint, empirically weaker estimated models, and socio-economic interest may need to be dropped in a model due to the strict utility theory.

Similarly the advantages of weak structural utility theory (WSUT) approach are that the functional form is more flexible allowing variables to be added in the model based on subjective judgment of the researcher, individual budget constraints is not imposed, more flexible model with less restricted applications, estimated models are empirically stronger, flexibility in model specification allowing better transfer, and follows less strict set of rules. The disadvantages of WSUT approach are that it follows less disciplined and less strict set of rules, utility theoretic model is an approximation specification, core economic and method (study design) variables may not be strictly consistent with utility theoretical model, reduced consistency, estimated models are theoretically weaker, and utility model provides weaker predictions.

This paper, therefore adopts the economic theory developed by Bergstrom & Taylor (2006) of “Weak Structural Utility Theoretic” (WSUT) model, which specifies the relationship between explanatory variables and an underlying utility function to capture heterogeneity in a

chosen model. It is one of systematic protocols developed to enhance knowledge in meta-analysis and to contribute benefit transfer knowledge base.

While developing economic model to estimate willingness-to-pay of policy site wetlands, a theoretical (also called stylized or simple) model, which represents a function of wetland characteristics and socio-economic characteristics may be considered. Formulating empirical models using the conceptual model varies depending on objective, type of goods and services being valued, spatial, and author's interests.

CHAPTER FOUR

METHODS

4.1. Site Selection

Two site types (study and policy sites) are key components in any benefit transfer analysis. The uniqueness of this approach is that it has two distinct site (1) where information (e.g., WTP) is already available i.e., the study site and (2) where information is being sought i.e., the policy site. Study site are the sites where research has already been undertaken. The research findings from study sites are then used in estimating values for policy sites. In essence, benefit transfer is a ‘plug into’ process of information from study site to policy site. In function transfer, the entire benefit function model is ‘transferred to’ to policy site.

Wetland valuation primary studies for the benefit transfer model or meta-regression model (MRM) were searched using the following sources: agecon search; google search; four existing meta-analyses focusing on the economic value of wetlands (Woodward & Wui, 2001; Borisova-Kidder, 2006; Brander et al., 2006; and Moeltner & Woodward, 2007); the database on Environmental Valuation Reference Inventory (EVRI) Canada; ScienceDirect; EconLit; a searchable database focusing on environmental non-market valuation studies; and a general searchable database of economic literature. These sources include peer reviewed journal articles, Ph.D. dissertations, Master thesis, government reports, consultants’ reports, university publications, and working papers. A wide range of studies were chosen in order to reduce publications bias and to set the desirable mix of papers in this benefit transfer study.

4.1.1. Study Sites and Criteria for Selection

This paper examined 26 contingent valuation, 15 replacement cost, and 1 benefit transfer based valuation studies (i.e., 21 papers) located in 8 different ERS region conducted from 1975 through 2012 (see Appendix 3), corresponding to 42 observations. Approximately 29 studies with

51 observations were selected initially. After screening the studies, only 21 study sites with 42 observations were included in the final selection. Specifically, 19 natural wetlands and 2 human-made wetlands were selected for the study sites. The reason for selecting human made wetland is to estimate and validate its values since benefit transfer study in human-made wetlands is rarely found. The valuation of human-made wetlands study is limited (Ghermandi et al., 2008).

The criteria for the selection of the study sites were:

- (i) Wetlands that are located in 48 contiguous states (excludes Hawaii, Alaska and other US territories),
- (ii) Wetlands that are inland and coastal located in the 48 contiguous states in the United States, and
- (iii) Wetlands that are included in this study are considered for biodiversity service which includes ecosystem (excludes special wetland services such as water quality, flood water control, and soil conservation) components.

In addition to the above criteria, study sites were chosen based on the suggestions of Desvousges et al. (1992). They suggested that studies should be based on (1) sound economic methods and correct empirical techniques, and (2) adequate data (reliable information). These scientific guidelines help to reduce transfer error (TE) or percentage difference of means in valuation studies. The selected 21 study sites (including two constructed wetland) for this research have good spatial coverage of the 48 contiguous states.

4.1.2. Policy Sites and Criteria for Selection

The policy sites were selected to best represent the spatial distribution of wetlands and based on pressing problems on these wetlands. These sites have also not been studied in terms of the value of services they provide (e.g., biodiversity). The wetlands included in the policy sites

were selected from Goodwin & Niering (1975). These wetlands were reported as threatened by anthropogenic stressors such as encroachment, water level manipulation, infrastructure development, excessive visitation, wildlife depredation, and trees cutting. If these stressors continue for years, all the wetlands will disappear. Therefore these fragile ecosystems must be protected through appropriate policy. The criteria for the selection of policy sites are the same as the study sites. In addition, the policy sites chosen should have similar socio-economic attributes and wetland attributes as those of the study sites included in this study.

Five natural wetland policy sites from across the United States have been selected one from each of the following state: New Jersey, Alabama, Florida, South Dakota/Minnesota, and Kentucky. The reason for selecting these policy sites is that they are under serious threats due to agricultural activities, water level manipulation, and excessive use of wetlands and utility infrastructures in or near these wetlands have triggered the loss of wetlands. One constructed wetland has also been included in the policy site. The reason for selecting constructed or human made wetland is that there is limited research conducted using benefit transfer in the United States on constructed wetlands (Ghermandi et al., 2008). This study attempts to estimate the economic value of such wetlands. All natural wetland policy sites are taken from Goodwin and Niering (1975) and the human-made wetland is taken from Gersberg et al. (1984). According to scientific classification provided by Cowardin et al. (1979), our study and policy sites fall under palustrine emergent (PEM), palustrine scrub-shrub (PSS), and palustrine forested (PFO) wetlands. One study site falls under the lacustrine littoral wetland system. The details of all the policy site wetlands are described below.

Policy site 1. Troy Meadows and Great Piece Meadows, New Jersey

Wetland: Troy and Great Piece Meadows

Type: Freshwater (PSS, PEM)

Area: 5,300 acres

Location: Essex & Morris counties, NJ

Services/goods: Wildlife preserve, ecosystem conservation

Threats:

- a) Storm water entering storm drains and carrying non-point source pollution, which is changing the ecology of the meadows;
- b) Silt pollution from surrounding suburban construction, which is filling in ancient Lake Passaic at an alarming rate;
- c) The excessive use of road salt, which is carried by storm water and polluting the freshwater marsh;
- d) The spread of invasive species of *Phragmites communis*, which is promoted by the salt and silt pollution;

(Threats as reported by Len Sunchild-Fariello, Land Manager, Wildlife Preserves).

- a) Troy Meadows and Great Piece Meadows are extended marsh and swamp portions of Lake Passaic with an area of 2,300 acres wetland. This swamp is considered as one of the most productive inland wetlands for wildlife in the eastern US. Both wetlands are under intense anthropogenic pressure such as utilities and highway system. Troy meadow is characterized by pin oak forest and cattail grasses and Great Piece Meadows has flood plain forest and swamp forest interspersed with Passaic River meander scars consisting 3,000 acres. National Park Service has listed these wetlands as Natural Landmark status in December 1970. These wetlands are in danger due to the following reasons: Troy and Piece Meadows are open to the public; there are literally hundreds of points of entry all around the meadows. The predominant visitors at Troy are bird watchers and at Piece are hunters. ATV riders are also users (and a big problem) at both meadows. Recent

- threats include a) Storm water entering storm drains and carrying non-point source pollution, which is changing the ecology of the meadows;
- b) Silt pollution from surrounding suburban construction, which is filling in ancient Lake Passaic at an alarming rate;
- c) The excessive use of road salt, which is carried by storm water and polluting the freshwater marsh;
- d) The spread of an invasive species *Phragmites communis*, which is promoted by the salt and silt pollution;
- e) The surrounding municipal water wells that are lowering the water table;
- f) At Black Meadows– the Morristown Airport– topping trees, killing birds and wildlife;
- g) At Troy Meadows– mosquito control– aerial spraying over the meadows;
- h) At Great Piece Meadows– mosquito control– ditching and draining the meadows;
- i) The high cost for a non-profit organization to manage the land, including the cost of defending it against all kinds of negative intrusions, eminent domain, roads, pipe lines, power lines, and the never ending political pressures for economic development; and
- j) Currently, the impending construction of the PSE & G Susquehanna-Roseland 230kV/500kV electric transmission line through Troy Meadows.

Figure 4. Troy Meadows and Great Piece Meadows, New Jersey

Policy site 2. Mobile Delta, AL

Wetland: Mobile Delta

Type: Freshwater (PEM, PSS)

Area: 65,000 acres

Location: Mobile & Baldwin counties, AL

Services/goods: Wildlife preserve, ecosystem conservation, it is considered one of the best natural marshes in the US

Threats:

- a) Industrial pollution (paper mills, ore deposits of aluminum, sewage, and chemical plants), shell dredging;
- b) Increased commercial development once the I-10 is in use.

Ownership: 45,000 acres, state of Alabama; 20,000 acres, private.

The Mobile Delta lies in southern Alabama that extends from the open Mobile Bay to Tombigbee Rivers covering a linear distance of approximately 40 miles. It is about 10 miles wide and, surrounded in on both sides by high land. This delta does not have woody vegetation at the lower one-quarter which represents marshes and bays, and the upper three quarters is covered by rivers, bays, bayous, and extensive swamp. The popular tree species are black gum, white bay, cypress, red maple, tupelo gum, ash, cottonwood, red bay, and willow. The lower third of this delta is considered one of the finest natural marshes in the United States (Beshears & Byrd, 1959). It is affected by salinity from 0.01 parts per thousand (ppt) in the spring months and from 1 to 3 ppt in the late summer and fall months. This delta is particularly rich in submerged, floating, and emergent vegetation. The upper reaches of the delta are predominantly covered by swamp bottomland forests.

Figure 5. Mobile Delta, Alabama

Policy site 3. Fahkahatchee Strand, FL

Wetland: Fahkatchee Strand, FL

Type: Freshwater (PEM, PFO)

Area: 75,000acres

Location: Collier County, FL

Services/goods: Wildlife preserve, ecosystem conservation

Threats:

- a) Hunting camps have been leased by Gulf American. These are located on the old railroad spurs off the scenic drive, occasional camps can be seen from the road;
- b) The area was relatively undisturbed when visited in the spring of 1969. However, in the spring of 1970 an extensive drainage canal was being constructed across the western section of the area; and
- c) If the drainage operation is continued or expanded it is highly possible that the water levels will be sufficiently lowered to destroy the biological values of the area as a whole and especially those along the scenic drive.

This wetland is located on the lower south end of Florida. It is rich in wilderness extending 4 miles wide and 15 miles long, which was owned originally by Turner Lumber Company and the area was cleared of trees in the late 1940s or early 1950s. This wetland's wilderness beauty is home to several mammals such as weasels, raccoon, deer, and several bird species and alligator. It is a 13-mile Janes Memorial highway that takes around one hour drive for an unbelievable wilderness area. The wetland had original forest of cypress, which is being replaced in part by willow scrub, red maple, and oak. Due to clear cutting of cypress trees, a severe fire had swept the area in 1961. This wetland area is rich and stands as a unique natural heritage of mature royal palms in south Florida, as well as the Paurotis palm.

Figure 6. Fakahatchee Strand, Florida

Policy site 4. Henderson Sloughs, KY

Wetland: Henderson Sloughs, KY

Type: Freshwater (PSS)

Area: ~5,000 acres

Location: Henderson & Union counties, KY

Services/goods: Wildlife conservation, ecosystem conservation

Threats:

- a) Public-funded agricultural practices and subsidies promote drainage and clearing, converting \$20 swamp land into \$400 farm land,
- b) Sloppy oil operations (spills and overflow of crude and salt water) cause chemical and mechanical damages to the area, and
- c) Wasteful timber harvest practices.

The slough lies in a triangular bend of the Ohio River between Smith Mills, Uniontown, and Mt. Vernon, Indiana. This slough is typical river-bottom hardwood habitat predominantly covered with oak-hickory, cottonwood, pecan, water-maple timber, and undulating terrain low ridges subject to annual overflow. The slough has a good population of deer and swamp-rabbit where previously populated with wild turkey. This wetland are extremely rich refuge for waterfowl and primarily ducks in pin-oak flats and geese, in flooded cornfields. This slough has a large population of fox, gray squirrels, raccoon, and furbearers.

Figure 7. Henderson Slough, Kentucky

Policy site 5. Club House Slough, SD

Wetland: Club House Slough, SD

Type: Freshwater (PEM, PSS)

Area: ~16,000acres

Location: Roberts county, SD and Traverse county, MN

Services/goods: Wildlife preserve, ecosystem conservation

Threats:

- a) Some of the marsh is being converted into agricultural use.
- b) U.S. Army Corps of Engineers' manipulations of water levels could endanger the area.

This wetland lies on the South Dakota- Minnesota border, but the majority of the area is in South Dakota. The slough stretches to the south approximately 10 miles from White Rock town, which is located in the northeastern corner of South Dakota. The average width of this slough is nearly 3 miles. This slough is characterized by shallow and deep marshes, which spread out along the Bois Des Sioux River. This slough is the headwaters of the Red River and was famous duck club located in White Rock. The Bois Des Sioux River has been channelized by the Corps of Engineers without a control structure. The slough still retains most of its natural appearance though it was channelized. The wetland area has a rich population of white-tailed deer, pheasants, ducks, and geese.

Figure 8. Club House Slough, South Dakota/Minnesota

Policy site 6. Human Made Wetlands in Santee, CA

According to Gersberg et al. (1984), the human-made wetlands in Santee, CA were designed primarily for wastewater treatment. In general, the constructed (or human-made) wetlands also offer refuge for wildlife and increase environmental aesthetics after many years. The area of the small four wetlands considered here is 0.77 hectares (see appendix 4).

Figure 9. Human-made Wetland, CA

4.2. Testing the Dataset

As mentioned previously, data used (i.e., study sites) in this study comes from existing valuation studies on both inland and coastal wetlands located in the conterminous United States. Several tests such as random and fixed effects, normality, multicollinearity, heteroscedasticity, and spatial autocorrelation were conducted to examine the suitability of the data before analysis.

4.2.1. Random and Fixed Effects Test

This test is important to know whether the study sites data is a panel data or not. Our data consist of study sites which have multiple observations in a single study. The typical regression model for a panel data structure is shown below.

$$y_{ab} = \alpha + \sum_{k=1}^K \beta_k X_{k,ab} + e_{ab} + u_b \quad \text{-----} \quad (4.1)$$

Where y is the dependent variable known as WTP in this equation, α is the constant term, β is the slope coefficient of explanatory variables, a is the number of study sites, b is the number of WTP estimates, X is the explanatory variables, k is the vector of explanatory variables, e_{ab} is the variance at the study level, and u_b is the variance at the estimates level. In SPSS, this test does not have direct way to calculate random and fixed effect size but R software was used.

4.2.2. Multicollinearity Test

This test examines the multiple correlations of sufficient magnitude that may have adverse effect on the regression equation. If there is multicollinearity then there is a violation of best linear unbiased estimators. Variance Inflation Factor (VIF) was used to test for multicollinearity. If VIF is less than 4, then there is no multicollinearity among the variables (Pan and Jackson, 2008). VIF measures the severity of multicollinearity in regression analysis or it provides an index of how much the variance is inflated due to multicollinearity.

4.2.3. Normality Test

A Q-Q plot for a single variable (i.e., WTP) was used to identify or detect normality in the dataset.

4.2.4. Heteroscedasticity Test

The Levene's test of equality of variances in the sample (homogeneity of variances) was used. The Levene's test was done using SPSS 22.0 version. Eye balling was also used to detect heteroscedasticity in a scatterplot to identify whether there is significant heteroscedasticity in the data.

4.3. Data Standardization

The wetland valuation studies were conducted at different time frame and in different scales of measurement. The information collected from journals, dissertations, and reports appear to be incomparable because they are reported in different scales. Therefore it is necessary to obtain a uniformity in scale such as area in hectare, WTP in US\$, and income in US\$. Majority of the studies used in the analysis reported WTP measures as WTP/hectare or WTP/household. The WTP/hectare can be converted from any reported units if relationship between wetland area hectare and number of households in the wetland area can be established. According to Woodward & Wui (2001) and Brander et al. (2006), the variables measured and reported in different units can be converted into desired unit such as WTP/hectare if there is an established relationship between wetland area and the relevant population being considered in study. The relationship may be explained using census data or other government databases and literature. Information about the underlying targeted population and wetland area can be used to convert from one to another unit. In this research, monetary figures were converted and indexed in US dollars 2012 year and wetland area was converted to hectare. The unit of WTP has been reported in US dollars per hectare. State level income was considered in order to bring uniformity in computation and analysis.

4.4. Economic Models in Benefit Transfer/Regression Models

4.4.1. Theoretical Model

A simple model is presented to explain the conceptual economic valuation of wetlands. Such model explains the basic concept in estimating the willingness-to-pay of wetlands as a function of wetlands' and socio-economic characteristics. The wetland characteristics may include area, altitude, region, and biogeochemistry. The socio-economic characteristics include but not limited to income, education, gender, race, and preference or attitude in conservation. The following theoretical model has been adopted by several meta-analysis and benefit transfer literatures (Leon-Gonzalez & Scarpa, 2008) in which an empirical model can be built from.

$$WTP_{ij} = \beta_0 + \beta_1 G_j + \beta_2 H_{ij} + \varepsilon_{ij} \quad \text{-----} (4.2)$$

Where WTP is willingness-to-pay of households, β_0 is intercept, β_i are parameters, G_j is wetland attributes and H_{ij} are socio-economic characteristics of households and ε_{ij} is error term associated with the study. The subscript i represents individual household and j represents site.

4.4.2. Empirical Models

Two sets of empirical models were estimated: 1) Variable-based, and 2) Functional form-based. The dependent variable for the models is willingness-to-pay (WTP) for wetland biodiversity conservation. The independent variables are household income (\$), wetland area (ha.), wetland types, Economic Research Service (ERS) regions, published year, publication of research, and valuation method. The description of the variables are presented in Table 2.

Table 2. Description of dependent and independent variables used in the models

Variables	Description
<i>Willingness-to-pay</i>	
Log.WTP	Log of willingness-to-pay of households (2012 US\$) per hectare per year.
<i>Income</i>	
INC	Income of households (2012 US\$) per year.
Log.INC	Log of income of households (2012 US\$) per year.
<i>Wetland area</i>	
AREA	Wetland area in hectares.
Log.AREA	Log of wetland area in hectares
<i>Wetland types</i> (dummy variable)	
FRESH SWAMP PRAIRIE HEM LAC COAST	Coded 1 if the wetland is Freshwater, 0 otherwise. Coded 1 if the wetland is Swamp, 0 otherwise. Reference category. Coded 1 if the wetland is High Elevation Moist, 0 otherwise. Coded 1 if the wetland is Lacustrine, 0 otherwise. Coded 1 if the wetland is Coastal, 0 otherwise.
<i>ERS region</i> (dummy variable)	
NE APPAL MTN NPLS DSP SE PAC	Coded 1 if the wetland is in Northeast, 0 otherwise. Coded 1 if the wetland is in Appalachian, 0 otherwise. Coded 1 if the wetland is in Mountain, 0 otherwise. Coded 1 if the wetland is in Northern Plains/Lake States, 0 otherwise. Coded 1 if the wetland is in Delta/Southern Plains, 0 otherwise. Coded 1 if the wetland is in Southeast, 0 otherwise. Reference category.
Published year (ordinal variable)	
YEAR	Published Year (ordinal variable, 1975=0, 1978=3, ----- 2012=37).
<i>Valuation method</i> (dummy variable)	
CVM RC BT	Reference category. Coded 1 if the valuation method is replacement cost (RC), 0 otherwise. Coded 1 if the valuation method is benefit transfer (BT), 0 otherwise.
Publication of research (dummy variable)	
PUB	Coded 1 if published in journal and books, 0 otherwise.

Variable-based approach has one full and three reduced models. The variable-based empirical models allow us to look at the contribution of a variable by dropping it the reduced model. The full model (model 1) is in log-log form and the three reduced models were developed by dropping one variable in each model. Specifically, variables representing wetland types, publication, and valuation method were dropped in model 2, model 3, and model 4 respectively. This allows the analyst to examine the magnitude of change in estimated coefficients caused by the omitted variable compared to the full model.

Similarly, functional form-based regression has four models. The functional form-based models were developed to explain the effects of the variable in marginal terms and elasticity. The first functional-based form model, which is model 5, is linear and includes all study sites or all observations. Model 6 is a reduced simple linear model that excludes one outlier observation (i.e., observation 9a). A Q-Q normality plot and a histogram were used to determine the outlier observation. Further, Tukey's test and Jarque-Bera (i.e., skewness & kurtosis) test were also used and found that there is one major outlier observation. Model 7 is a full log-log model with all study sites, and model 8 is a reduced log-log that excludes the outlier.

In the variable-based approach, continuous variables were transformed into log form in order to facilitate computation and making highly skewed variable such as AREA normally distributed. This transformation also reduces the problem of heteroscedasticity.

There are several reasons for choosing log-linear model in this paper. First, the log-log model brings down the large coefficient estimates into small size. Second, it is easy to use and interpret the coefficient estimates in terms of elasticity or percentage. Third, it helps to reduce the problem of heteroscedasticity in the models. Fourth, it helps to narrow down the residuals and improves normal distribution.

4.4.2.1. Variable-based Models

The full description of all the study site models of study sites are given below:

Model 1: Full Model

The wetlands' WTP for biodiversity conservation in the United States is represented by the following regression model.

$$\begin{aligned} \log.WTP = & \beta_0 + \beta_1.\log.INC + \beta_2.\log.AREA + \beta_3.NE + \beta_4.APPAL + \beta_5.MTN \\ & + \beta_6.NPLS + \beta_7.DSP + \beta_8.PAC + \beta_9.FRESH + \beta_{10}.SWAMP + \beta_{11}.PRAIRIE \\ & + \beta_{12}.HEM + \beta_{13}.LAC + \beta_{14}.COAST + \beta_{15}.PUB + \beta_{16}.CVM + \beta_{17}.RC \\ & + \beta_{18}.BT + \beta_{19}.YEAR + \varepsilon \end{aligned} \quad \text{----- (4.3)}$$

The main purpose for the inclusion of household income variable in the model is guided by the relationship of income and willingness-to-pay of local people or users in resource conservation. The median household income used in all empirical models is converted to 2012 US dollars using the Bureau of Labor Statistics (BLS) inflation calculator. Some studies have not reported median household income and in that case, the US census reported income at the state level has been used where the household income is missing. The reason for using the state level income is to facilitate computation. Wetland area was included as an independent variable in the models as it is associated with the law of production function. The laws of production function are increasing returns to scale, constant returns to scale, and decreasing returns to scale. These returns to scale are very useful in analyzing the estimated coefficient of wetland area in the selected model(s) as in Woodward & Wui (2001). Thus, inclusion of area is important in our analyses. According to Ghermandi (2008), wetland size may be an influential factor in valuation process. In this research, the size of wetland varies from very small (3 acres) to very large (429,000 acres).

Previous studies have found that the locational variable significantly affect wetland values (Woodward & Wui, 2001). This variable is important as location and people's attitude in natural resource conservation differs significantly. Thus, this study included ERS region as a variable in the model. This study covers seven different USDA ERS region. The regions are Northeast, Appalachian, Southeast, Delta/Southern Plains, Northern Plains/Lake States, Mountain, and Pacific. Another variable included in the model is wetland type. The productivity or service of wetland varies based on its type. There are six different types of wetland included in the model: freshwater, swamp, prairie pothole, high elevation moist, lacustrine, and coastal. As we know, different type of wetlands perform differently and therefore they are valued based on the ecological services they offer. Study year was included in the model is to examine the effect of particular time period of study on willingness-to-pay for biodiversity conservation.

Study year was included in the model to examine the effect of particular time period of study on willingness-to-pay for biodiversity conservation. The study year variable represents the number of years from when the first wetland valuation study was undertaken (i.e., 1975 to 2012) and when the study being used was conducted. This ordinal variable attempts to capture temporal and users' preference in a particular time period. Finally, valuation methodology was included in the model as willingness-to-pay of wetland produced by different methods may vary. The valuation methods used in the study sites were contingent valuation, replacement cost, and benefit transfer.

In addition to the full model, the following reduced models were also proposed to examine the change in coefficient estimates by dropping one variable in each model. This approach is useful to examine the impact of the variable that was dropped on WTP.

Model 2: Double log functional form dropping wetland type variables

This model examines WTP by ignoring the systematic variation of wetland types. The regression model is shown below:

$$\begin{aligned} \log.WTP = & \beta_0 + \beta_1.\log.INC + \beta_2.\log.AREA + \beta_3.NE + \beta_4.APPAL + \beta_5.MTN \\ & + \beta_6.NPLS + \beta_7.DSP + \beta_8.PAC + \beta_9.FRESH + \beta_{10}.SWAMP + \beta_{11}.PRAIRIE \\ & + \beta_{12}.HEM + \beta_{13}.LAC + \beta_{14}.COAST + \beta_{15}.PUB + \beta_{16}.CVM + \beta_{17}.RC \\ & + \beta_{18}.BT + \beta_{19}.YEAR + \varepsilon \end{aligned} \quad \text{----- (4.4)}$$

Where Log.WTP is dependent variable in log form of an individual household in US dollars, β_0 is the intercept, β_i are coefficient estimates of explanatory variables, and variables are as defined in model 1.

Model 3: Double log functional form dropping valuation method variables

This model attempts to examine the WTP by ignoring the systematic variation of methods used in valuation:

$$\begin{aligned} \log.WTP = & \beta_0 + \beta_1.\log.INC + \beta_2.\log.AREA + \beta_3.NE + \beta_4.APPAL + \beta_5.MTN \\ & + \beta_6.NPLS + \beta_7.DSP + \beta_8.PAC + \beta_9.FRESH + \beta_{10}.SWAMP + \beta_{11}.PRAIRIE \\ & + \beta_{12}.HEM + \beta_{13}.LAC + \beta_{14}.COAST + \beta_{15}.PUB + \beta_{16}.YEAR + \varepsilon \end{aligned} \quad \text{----- (4.5)}$$

Where Log.WTP is dependent variable in log form of an individual household in US dollars, β_0 is the intercept, β_i are coefficient estimates of explanatory variables, and variables are as defined in table 2.

Model 4: Double log functional form dropping PUB variable.

This model ignores the systematic effects of publishing research outcomes in peer-reviewed journals or in gray literature. The proposed model is as follows:

$$\begin{aligned} \log.WTP = & \beta_0 + \beta_1.\log.INC + \beta_2.\log.AREA + \beta_3.NE + \beta_4.APPAL + \beta_5.MTN \\ & + \beta_6.NPLS + \beta_7.DSP + \beta_8.PAC + \beta_9.FRESH + \beta_{10}.SWAMP + \beta_{11}.PRAIRIE \\ & + \beta_{12}.HEM + \beta_{13}.LAC + \beta_{14}.COAST + \beta_{15}.CVM + \beta_{16}.RC + \beta_{17}.BT + \beta_{18}.YEAR + \varepsilon \end{aligned}$$

----- (4.6)

Where Log.WTP is dependent variable in log form of an individual household in US dollars, β_0 is the intercept, β_i are coefficient of explanatory variables, and variables are as defined in table 2.

4.4.2.2. Functional Form-based Models

The full functional form-based log-log model (model 7) is identical to the full log-log variable-based model (model 1). The functional form-based models include linear and log forms and these models do not have any variables dropped but one observation is dropped in reduced models. There are several reasons for choosing log-linear model in this paper. First, the log-log model brings down the huge figure into small number. Second, it is easy to use and interpret the coefficient estimates in terms of elasticity or percentage. Third, it helps to reduce the problem of heteroscedasticity in the models. Fourth, it helps to narrow down the residuals and improves the distribution.

Models 5 & 6: Full & reduced linear model

$$\begin{aligned} WTP = & \beta_0 + \beta_1.INC + \beta_2.AREA + \beta_3.NE + \beta_4.APPAL + \beta_5.MTN \\ & + \beta_6.NPLS + \beta_7.DSP + \beta_8.PAC + \beta_9.FRESH + \beta_{10}.SWAMP + \beta_{11}.PRAIRIE \\ & + \beta_{12}.HEM + \beta_{13}.LAC + \beta_{14}.COAST + \beta_{15}.CVM + \beta_{16}.RC + \beta_{17}.BT + \beta_{18}.YEAR + \varepsilon \end{aligned}$$

----- (4.7)

Where β_0 is the intercept, β_i are coefficients of variables. 2.

Models 7 & 8: Full and reduced log-log models

$$\begin{aligned} \log.WTP = & \beta_0 + \beta_1.\log.INC + \beta_2.\log.AREA + \beta_3.NE + \beta_4.APPAL + \beta_5.MTN \\ & + \beta_6.NPLS + \beta_7.DSP + \beta_8.PAC + \beta_9.FRESH + \beta_{10}.SWAMP + \beta_{11}.PRAIRIE \\ & + \beta_{12}.HEM + \beta_{13}.LAC + \beta_{14}.COAST + \beta_{15}.PUB + \beta_{16}.CVM + \beta_{17}.RC \\ & + \beta_{18}.BT + \beta_{19}.YEAR + \varepsilon \end{aligned} \quad \text{----- (4.8)}$$

Where β_0 is the intercept, β_i are coefficients of variables.

4.4.2.3. Empirical Model of Policy Sites

The empirical model for policy site is developed based on the available variables in these sites.

$$\begin{aligned} \log.WTP = & \beta_0 + \beta_1.\log.INC + \beta_2.\log.AREA + \beta_3.NE + \beta_4.APPAL \\ & + \beta_5.NPLS + \beta_6.PAC + \beta_7.FRESH + \beta_8.PUB + \beta_9.BT + \beta_{10}.YEAR + \varepsilon \end{aligned} \quad \text{----- (4.9)}$$

Where β_0 is the intercept, β_i are coefficients of variables. This benefit transfer research at policy sites was initiated in 2012. If we consider the oldest study site conducted by Gupta & Foster in 1975, these policy sites are being studied after 37 years.

Before estimating the empirical model, some adjustments have been made to the wetland type and ERS region variables. Some categories were combined based on the ecological nature and their geographical relatedness. For example, the categories combined in ERS variable are Northern Plains/Lake States and Delta/Southern Plains. This combination helps to obtain more robust estimates.

4.5. Validity Testing

In performing validity testing, original and estimated WTP need to be estimated. In order to examine validity, models 7 and 8 were used. The reasons for choosing these two models were the inclusion of all the variables being examined in both models and the transformation of these models into log functional form. The validity tests were performed by dropping one observation at a time and running an ordinary least square (OLS) regression each time and then comparing the results with hypothesized tests for validity. The purpose of dropping one variable at a time when running an OLS regression is to obtain another comparable WTP estimates for study sites for the validity test. In meta-analysis & benefit transfer essence, policy sites are always selected with few sample size as compared to study sites, which (i.e., policy sites) do not provide robust and reliable coefficients to plug in study sites. This method is acceptable because of larger sample size in study sites than in the policy sites. The author-reported (original) and estimated (projected) WTP values are shown in results section.

It is important to calculate estimated WTP for study sites in order to perform the validity tests without which validity tests cannot be done. The number of observations in policy sites (n=6) are not sufficient to perform validity tests. Thus, estimated WTP for study sites was used.

The main objective of validity test is to compare benefit estimates of previous studies with the new estimated benefit estimates of study sites. The validity tests examine if original (author reported) and estimated (projected) WTP are transferable in similar valuation research. This research paper follows the validity tests recommended by Shrestha & Loomis (2003):

Validity Test # 1 Percentage Difference between original WTP and estimated WTP (Transfer error)

$$\text{Transfer error} = \frac{(\text{WTP}_{\text{estimated}} - \text{WTP}_{\text{original}})}{\text{WTP}_{\text{original}}} * 100 \quad \text{-----} \quad (4.10)$$

Transfer error (TE) arises due to the differences in original (author reported) WTP and estimated (projected) WTP. It is sometimes also called percentage error. It is a direct and simple validity test. In the case of underestimated transfer error, the negative transfer error is measured in absolute values. It measures the difference between original (author reported) and estimated (projected) WTP. According to Loomis & Shrestha (2003), transfer error can range from a small percentage to several hundred percent. Loomis et al. (1995) has as high as 475% transfer error and Kirchhoff et al. (1997) have reported 6-228% transfer error.

Validity Test # 2 Equality of original WTP and estimated WTP values

$$\begin{aligned} H_0 &= \delta_a = 0 \\ H_1 &= \delta_a \neq 0 \end{aligned} \quad \text{----- (4.11)}$$

Where δ_a is the mean difference between original and estimated WTP values.

The equality of WTP values can be examined using paired t-test (original and estimated WTP amounts) of means. The null hypothesis is that original and estimated WTP values are equal and the alternate hypothesis is they are different. If the null hypothesis is accepted, then the mean original WTP and estimated WTP are equal or they converge to each other. The null hypothesis should be accepted to prove equality of mean WTP values. Rejection of the null hypothesis indicates that the original and estimated WTP are different. Therefore it is better if we fail to reject the null hypothesis to get the equality of mean of both WTP estimates.

This test has been performed in several ways by several authors. Brouwer and Spaninks (1999) used the Kolmogorov-Smirnov test while Shrestha & Loomis (2003) prefer using paired t-test. The Kolmogorov-Smirnov test is rarely used and thus it is not used here too. This research took the approach suggested by Shrestha & Loomis (2003). Since we need to examine distributional pattern of two different types of WTP, a paired t-test is ideal.

Validity Test # 3 Functional relationship (variability) between original and estimated WTP

$$\begin{aligned} H_0 : \beta_0 = 0, \beta_1 = 1 \\ H_1 : \beta_0 \neq 0, \beta_1 \neq 1 \end{aligned} \quad \text{-----} \quad (4.12)$$

Using an Ordinary Least Square (OLS) regression, a functional relationship (variability) of the original WTP and estimated WTP amounts is examined. A joint F-test was used to test this validity. If β_0 is zero & β_1 is equal to one, then original WTP and estimated WTP are equal and satisfy the validity of benefit transfer. The null hypothesis is that the original and estimated WTP amounts are similar and the alternate hypothesis is that there is difference between original and estimated WTP amounts. Horowitz & Louviere (1993) recommended equation 4.13a for this test.

$$WTP_{original} = \beta_0 + \beta_1 WTP_{estimated} + error \quad \text{-----} \quad (4.13a)$$

Or

$$F = \frac{SSR_r - SSR_{ur} / q}{SSR_{ur}(n - k - 1)} \quad \text{-----} \quad (4.13b)$$

Where SSR_r stands for residual sum of squares of the restricted regression, SSR_{ur} is the residual sum of squares of the unrestricted regression, q is the restriction applied, and k is the number of independent variables used to test. A restriction was imposed to perform joint F-test as β_0 is zero and β_1 is one. This test is a rigorous test, however, a less stringent null hypothesis makes it less robust. Failing to reject null hypothesis at 10% level indicates there is no variation in original and estimated WTP amounts and therefore they converge to each other.

Validity Test # 4 Correlation between original and estimated WTP amounts

This is another way to test the validity in benefit transfer research. It is a stringent test if and only if the null hypothesis is considered an upper bound of Pearson's correlation (+1) as this

is perfectly positive correlation. Our assumption is that the original (author reported) and estimated (projected) WTP values are perfectly correlated. Carson et al. (1996) used Pearson's correlation to test for validity. The null hypothesis is that the original (author reported) WTP and estimated (projected) WTP are not correlated while the alternate hypothesis is that the two WTP estimates are correlated. The rejection of null hypothesis indicates that there is a correlation between estimated and original WTP. Strongly correlated WTP estimates lend a greater potential for transferability. The summary of validity tests is shown below:

Table 3. Validity testing procedure

Test #	Validity tests	Econometric tool	Hypothesis	Acceptance/rejection criterion
1	% difference between original WTP and estimated WTP or transfer error (TE)	Percentage error	$\delta = \left(\frac{WTP_{estimated} - WTP_{original}}{WTP_{original}} \right) * 100$ <p>δ is the transfer error</p>	Smaller transfer error (TE)
2	Equality of original WTP & estimated WTP	Paired t-test	$H_0 : \theta_d = 0$ $H_1 : \theta_d \neq 0$ <p>Θ_d is mean difference between original & estimated WTP</p>	We need to have condition that fails to reject null hypothesis, then original & estimated WTP are similar
3	Variability (functional relationship) between original WTP & estimated WTP	Joint F test	<p>Null hypothesis: $\beta_0=0, \beta_1=1$</p> <p>Alternate hypothesis: $\beta_0 \neq 0, \beta_1 \neq 1$</p>	We need to have condition that fails to reject null hypothesis, then original & estimated WTP are similar
4	Correlation (r) between original estimated WTP	Pearson's correlation (r)	$H_0 : r = 1$ $H_1 : r < 1$	Positive and high correlation

4.6. Estimation of WTP for Policy Sites

In order to meet objective one, it is necessary to estimate willingness-to-pay for the policy sites. The WTP for policy sites can be calculated using estimated coefficients from the study site models. The household income data for each of these sites were obtained from 2010 US census report. The area of these wetlands were obtained from Goodwin & Niering (1975). The valuation year for the policy sites is 2012 and the valuation method is benefit transfer. Each of the policy sites was a freshwater wetland. The WTP amounts of policy sites were calculated using the following equation.

$$WTP_{\text{policysite}} = f_s(\hat{\beta}, X_p) \text{-----} (4.14)$$

Where $WTP_{\text{policysite}}$ is the willingness-to-pay for policy sites, β is the estimated coefficient of study sites, which are then used as models 7 & 8 coefficients for the independent variables of policy sites.

If the study site original WTP are predominately underestimated, then estimated WTP at policy sites can be assumed to be underestimated with the benefit transfer model (although there is no comparison base to confirm). Thus, estimated WTP needs to be adjusted. In wetland valuation literature, adjusted WTP at policy sites are currently not available. Instead, $WTP_{\text{policysite}}$ is typically the benefit transfer value placed on policy sites. However, the TE calculations from the validity tests can be used to compute an adjusted WTP at policy sites. This approach only works if the benefit transfer model predominately overestimates or underestimates the original WTP. No literature was found that makes such an adjustment, therefore this approach is introduced here as a pioneer work in this dissertation. The necessary adjustments were made using the following equation.

$$TE = [(WTP_{est} - WTP_{adj}) / WTP_{adj}] * 100 \quad \text{----- (4.15a)}$$

Or

$$WTP_{adj} = WTP_{est} / [(TE/100) + 1] \quad \text{----- (4.15b)}$$

WTP_{est} is the benefit transfer estimate for the policy site and when WTP are underestimated on the study sites, TE is negative. Thus, WTP_{adj} is the adjusted policy site WTP and WTP_{est} is adjusted upwards based on transfer errors being predominantly negative. In the case our models do not pass all validity tests, then we recommend the adjustment of WTP values at policy sites.

CHAPTER FIVE

RESULTS

This section presents three main results from this study. The first part presents descriptive statistics of the variables used in the models. The second section presents results of the meta-regression models. The last section presents results of the validity tests performed.

5.1. Descriptive Statistics

This section includes descriptive statistics of study sites and policy sites. The descriptive statistics of the variables used in study site models is presented in Table 4 below.

Table 4. Descriptive statistics of independent variables used in the study site models

Variable	Mean	Min.	Max.	Std. Dev.
YEAR	15.67	0	37	9.94
CVM	Reference	Reference	Reference	Reference
BT	0.02	0	1	0.15
RC	0.35	0	1	0.45
INC	53,417.62	40,196.00	65,339.00	8,657.07
Log.INC	4.72	4.62	4.81	0.07
FRESH	0.69	0	1	0.46
-	0.09	0	1	0.29
HEM	0.02	0	1	0.15
PRAIRIE	Reference	Reference	Reference	Reference
LAC	0.02	0	1	0.15
COAST	0.04	0	1	0.21
NE	0.24	0	1	0.43
MTN	0.04	0	1	0.21
PAC	Reference	Reference	Reference	Reference

APPAL	0.12	0	1	0.32
NPLS	0.28	0	1	0.46
SE	0.12	0	1	0.32
DSP	0.04	0	1	0.21
Log.AREA	3.29	0.08	5.52	1.24
AREA	16,684.00	1.2	335,591.4	52,038.86
PUB	0.60	0	1	0.49

Comparison of variables used in the study site and policy site models are presented in table 5. Income is approximately equal in both study sites and policy sites. The number of ERS regions covered by wetlands is different between the study sites and policy sites. The study sites covered 8 regions while the policy sites only covered 5 regions. There are six different types of wetlands found in study sites whereas only freshwater wetlands were considered in policy sites. The wetland area was slightly larger in the study sites compared to the policy sites. The valuation method used in the study sites were contingent valuation, replacement cost and benefit transfer while only benefit transfer method was used in the policy site.

Table 5. Comparison of study sites and policy sites by variables used in the models

Comparison variables	Study sites	Policy sites
Average INC (\$)	53,531.81	54,356.00
Average Log.INC (\$)	4.72	4.73
Average AREA (ha.)	16,684	11,214.29
Average log.AREA (ha.)	3.29	2.96
Number of ERS regions	8	5
Number of wetland types	6	1
Number of valuation methods	3	1

The mean original or author reported WTP reported in study sites by wetland types is presented in Table 6. High elevation moist wetland in West Virginia has the lowest mean WTP (\$) and the coastal wetlands in Louisiana and Michigan have the highest mean WTP. The freshwater wetlands, which accounts for about 70% of the total wetland type in this dataset is close to the coastal wetland in mean WTP. Coastal wetland study sites have higher WTP than any other type.

Table 6. Wetland values in study sites by wetland types

Wetland types	Mean WTP (\$)
Coastal (2)*	2,041.74
Freshwater (30)	1,000.00
High elevation moist (1)	8.13
Lacustrine (1)	74.13
Prairie potholes (5)	42.66
Swamp/Peat (3)	40.74

* The number in parenthesis are number of wetlands studied.

The author reported (original) WTP amount varies greatly by method selected in wetland valuation. Literature claims that CVM produces lower WTP estimates (Woodward & Wui, 2001). According to author reported (i.e., original) WTP from studies sites, mean WTP computed using benefit transfer was higher than contingent valuation and replacement cost (see Table 7).

Table 7. Wetland values in study sites by valuation method

Method	Mean WTP(\$)
Benefit Transfer (1)*	2,454.71
Contingent Valuation (26)	489.77
Replacement Cost (15)	301.99

*The number in parenthesis are frequency of methods used in studies.

Wetland valuation literature often includes location (spatial attribute) as an independent variable in the model. As shown in Table 8, the Pacific ERS region had the highest mean WTP estimates and Mountain region had the lowest mean WTP. Pacific and Delta/Southern Plains regions have comparatively very high WTP values than other ERS regions.

Table 8. Wetland values in study sites by ERS region

ERS region	Mean WTP(\$)
Northeast (10)*	524.81
Appalachian (5)	41.69
Mountain (2)	14.45
Northern Plains/Lake States (12)	758.58
Delta/Southern Plains (2)	3,235.94
Southeast (5)	85.11
Pacific (6)	3,630.78

*The number in parenthesis are number of wetlands found in ERS region.

5.2. Dataset Tests

5.2.1. Random and Fixed Effects

The R statistical software was used to detect random and fixed effects. The p-value is statistically not significant ($p > 0.10$), which rejects random effect in our sample. The panel linear model was used to perform this test in R statistical software.

5.2.2. Multicollinearity Test

The variance inflation factor (VIF) for INC, AREA, and WTP are below 2, which indicate that there is no multicollinearity among these variables. The VIF (also known as diagnostic test to detect multicollinearity) tells that how much the variance of a coefficient is inflated with other independent variables in linear form. The VIF for categorical variables can safely be ignored since these variables have three or more categories except PUB (Allison, 2012). The VIF is below the threshold level ($VIF < 4.0$) for all variables and therefore it indicates there is no multicollinearity among these variables (Pan & Jackson, 2008). The other independent variables were categorical variables and were not tested for collinearity.

5.2.3. Normality Test

A Q-Q plot of original WTP (see Figure 10) shows that the data are approximately normal except for some outliers and therefore the data can be assumed to be normally distributed.

Figure 10. Normal Q-Q plot of log.WTP

Figure 11. Scatterplot of WTP (\$), income (\$) and wetland area (ha.)

Figure 11 shows that log.WTP has more concentration in the middle continuum with log.AREA and in the lower and middle continuum with log.INC. The log.AREA is more concentrated in the middle continuum with log.INC and lower and middle continuum with log.WTP. Similarly, log.INC is more concentrated in middle continuum with log.WTP and log.AREA. This scatterplot shows that the selected dataset is approximately normally distributed.

5.2.4. Heteroscedasticity Tests

A Levene's test of SPSS was performed and showed that the data are homoscedastic (i.e., variances in the error terms are constant). Results indicate that p-value was greater than 0.05 for wetland types, method, and log.WTP, which suggests equality of variance/homoscedastic among these variables. Econometricians agree that minor heteroscedastic problems can be corrected by transformation unless the problem is severe. The p-values of income, area, year, ERS, and publication variables were below 0.10 and therefore the data are homoscedastic at 10% significance level. This indicates there are equality of variances with the dependent variable log.WTP. This problem is reduced in the empirical models by transforming the continuous variables (INC, AREA) into log form.

5.3. Results of Meta-Regression Models

The results of the variable-based models are shown in Table 9. Models 1 through 4 are computed and shown for comparisons only. One variable type was dropped in each model except model 1, which is a full model. Models 2 to 4 do not have all variables for further analysis, which is one of the reasons not to include these models for validity tests, WTP estimation at policy sites, and adjustment of WTP values at policy sites.

Table 9. Meta-regression results of the variable-based models of study sites.

Variables	Model 1	Model 2	Model 3	Model 4
Constant	-109.51 (50.50)**	63.476 (36.64)*	-111.10 (50.52)**	-83.64 (50.32)
Log.AREA	-0.03 (0.17)	-0.01 (0.18)	-0.09 (0.16)	0.21 (0.14)
Log.INC	23.34 (10.47)**	-12.37 (7.62)	23.67 (10.48)**	17.61 (10.46)*
YEAR	-0.06 (0.04)	-0.05 (0.04)	-0.06 (0.04)	-0.04 (0.03)
NE	-1.47 (0.84)*	0.38 (0.81)	-1.83 (0.76)**	3.09 (0.71)
APPAL	2.21 (1.71)	-3.19 (0.99)***	2.07 (1.70)	1.17 (1.02)
MTN	0.11 (1.07)	-2.73 (1.08)**	0.32 (1.06)	1.24 (1.40)
DSP	3.82 (1.69)**	-1.93 (1.47)	3.47 (1.66)**	0.11 (0.87)**
NPLS	2.85 (0.85)***	-0.48 (0.69)	2.82 (0.85)***	1.99 (1.39)**
SE	1.41 (1.48)	-3.24 (1.26)**	1.55 (1.48)	-1.52 (0.91)
FRESH	3.27 (0.70)***	dropped	3.27 (0.70)***	1.64 (1.71)***
SWAMP	1.15 (0.93)	dropped	1.16 (0.93)	-0.21 (1.16)
HEM	1.53 (1.28)	dropped	1.95 (1.22)	2.89 (1.23)
LAC	-0.45 (0.84)	dropped	-0.02 (0.81)	2.19 (0.87)
COAST	2.52 (1.27)*	dropped	2.77 (1.25)**	1.08 (1.48)
RC	-1.42 (0.68)**	-1.75 (0.79)	-1.35 (0.68)*	Dropped
BT	-1.23 (1.45)	1.95 (1.64)	-1.11 (1.45)	Dropped
PUB	-0.39 (0.38)	0.04 (0.43)	dropped	-0.22 (0.41)
R ²	80.5%	57.0%	79.6%	74.2%
Adjusted-R ²	66.6%	39.2%	66.5%	59.3%
n	42	42	42	42

* Significant at 10% level, ** Significant at 5% level, and *** Significant at 1% level.
Standard errors are in parenthesis.

In the variable-based models, the YEAR variable is not significant across all models. Log.AREA is also not significant across all models. This indicates that year and wetland area do not contribute significantly in explaining WTP values of wetlands. Log.INC is positive and is statistically significant across models 1, 3, and 4, which suggests that an increase in income will result in an increase in wetland values (i.e., 1% increase in income causes wetland value to increase by 23.34% in model 1). In terms of variables representing ERS regions, APPAL, MTN, and SE are negative and statistically significant in model 2 but are not significant in any other models, which indicates that these regions have lower WTP estimates compared to the Pacific region (the reference category). The other ERS region variables like DSP and NPLS are positive and statistically significant in models 1, 3 and 4, which indicates that that WTP estimates from these regions are higher compared to the Pacific region. Among all the variables representing wetland types, FRESH is the only one which is statistically highly significant ($p < 0.01$) across all three models except where it was dropped or omitted. It has a positive coefficient in these models, which indicates that WPT estimates/values from these wetlands higher relative to prairie wetlands. Similarly, COAST is positive but only statistically significant in models 1 and 3. Among the variables representing valuation method, only RC is significant and negative, which indicates that WTP estimate using the replacement cost method is lower compared to CVM (reference category). PUB is not significant across all models.

Based on the model fit of the variable-based models, models 1, 3, and 4 have adjusted- R^2 around and above 60% while model 2 has 39.2%. This smaller adjusted- R^2 in model 2 implies that dropping wetland types variables (FRESH, SWAMP, HEM, LAC, and COAST) from the model severely penalized the overall goodness-of-fit of the model. This drop in the adjusted- R^2 may due to the significance of FRESH, SWAMP, and COAST variables in model 1 and dropping these

impact the goodness-of-fit in model 2. Dropping the PUB, RC, and BT variables in models 3 and 4 confirms that these variables do not explain the variation in WTP strongly.

The results of regression models using the functional form approach are presented in table 10 below. The AREA variable is statistically significant in models 5 and 6 but Log.AREA is not significant in models 7 and 8. In addition, the variables representing AREA show inconsistent signs, negative in models 5 and 6 and positive in models 6 and 8. The coefficients of AREA in models 5 and 6 indicate that WTP declines by 1.93 times and increases by 0.17 time, respectively. The coefficients of log.AREA in models 7 and 8 indicate that WTP is declining by 0.03% and increasing by 0.23%, respectively.

Table 10. Meta-regression results of all models of study sites (*functional form-based*)

Variables	Model 5	Model 6	Model 7	Model 8
Constant	-2,652,800.26 (1,090,290.69)**	276,585.44 (121,976.01)**	-109.51 (50.50)**	-66.35 (51.87)
AREA	-1.93 (0.76)**	0.17 (0.09)*	-	-
Log.AREA	-	-	-0.03 (0.17)	0.23 (0.20)
INC	49.19 (17.86)**	-4.99 (2.06)**	-	-
Log.INC	-	-	23.34 (10.47)**	14.08 (10.82)
YEAR	-17,569.69 (7,598.79)**	1,043.45 (846.53)	-0.06 (0.04)	-0.03 (0.04)
NE	-279,415.57 (170,697.68)	35,820.57 (17,957.13)*	-1.47 (0.84)*	-1.06 (0.81)
APPAL	767,570.94 (306,458.47)**	-84,414.79 (34,050.49)**	2.21 (1.71)	1.11 (1.69)
MTN	502,725.32 (207,635.69)**	-59,984.17 (23,616.37)**	0.11 (1.07)	-0.49 (1.05)
DSP	755,957.73 (274,157.94)**	-48,983.18 (30,200.19)	3.82 (1.69)**	2.99 (1.64)*
NPLS	750,120.66 (186,400.28)***	-43,240.71 (24,155.27)*	2.85 (0.85)***	1.63 (0.99)
SE	604,898.54 (257,317.33)**	-76,475.10 (29,056.07)**	1.41 (1.48)	0.67 (1.44)
FRESH	248,860.79 (118,936.45)**	-747.11 (12,057.22)	3.27 (0.70)***	2.33 (0.80)***
SWAMP	123,011.82 (155,384.27)	12,142.99 (15,266.89)	1.15 (0.93)	0.62 (0.91)
HEM	140,606.76 (195,395.32)	6,552.78 (19,219.94)	1.53 (1.28)	0.62 (1.28)
LAC	-342,580.99 (156,902.52)**	10,861.24 (16,969.99)	-0.45 (0.84)	-0.13 (0.80)
COAST	172,686.69 (187,486.85)	-25,122.41 (18,938.19)	2.52 (1.27)*	1.25 (1.34)
RC	-403,608.52 (122,394.85)***	14,204.16 (14,580.99)	-1.42 (0.68)**	-0.21 (0.87)
BT	-64,358.01 (243,775.34)	-9,774.64 (23,749.42)	-1.23 (1.45)	-1.08 (1.37)
PUB	-130,733.94 (62,260.89)**	-65,452.23 (12,325.52)	-0.39 (0.38)	-0.09 (0.39)
R ²	57.7%	46.2%	80.5%	79.1%
Adjusted-R ²	27.8%	10.3%	66.6%	63.6%
n	42	41	42	41

* Significant at 10% level, ** Significant at 5% level, and *** Significant at 1% level
Standard errors are in parenthesis; Sites 9a is deleted as outlier in reduced models.

The INC/log.INC variable is positive in models 5, 6, and 8 and statistically significant in these models at or below 5% level but note that it has negative sign in model 6, which is contrary to expectation. This negative sign of INC indicates that as income increases by \$1, WTP decreases by \$4.99. In this case, economic intuition tells us that people are considering wetland as inferior good. On the other hand, the results in models 5, 7, and 8 (reduced log-log) indicate that income is positively related to WTP. This means that wetland is regarded as a normal good. That is, as income of household increases, the WTP for conservation of wetland also increases. The YEAR variable is statistically significant in model 5 only and has a negative sign, which indicates that WTP estimates from later publications have lower WTP estimates compared to those coming from earlier publications.

With respect to variables representing ERS regions, the NE variable is negative but statistically significant at 10% level in models 6 and 7, which suggests NE region has lower WTP as compared to PAC region (reference category). MTN variable is statistically significant at or below 5% level in models 5 and 6 and show conflicting signs. For example, using model 5, WTP from MTN will be higher compared to PAC region but model shows that WTP from MTN is lower relative to PAC. DSP is positive and significant in models 5, 7 and 8, which indicates that WTP is higher from this region compared to PAC region. The NPLS variable is positive and significant in models 5 and 7 and negative and significant in model 6. SE region is positive and significant in model 5 but negative and significant in model 6. This is another example where the results of the different models provide conflicting signs.

With regards to wetland types, FRESH (freshwater wetland) is positive and highly statistically significant in models 5, 7, and 8. Looking at model 8, WTP increases by 2.33% if the wetland type is FRESH (i.e., freshwater wetland) as compared to PRAIRIE wetland (reference

category). On the other hand, WTP from SWAMP and HEM wetlands are not statistically significantly different from PRAIRIE wetland. LAC wetland is statistically significant only in model 5 and has a negative sign. This means that WTP from LAC is lower compared to PRAIRIE wetland. COAST is positive and only significant in model 7.

With respect to the valuation methods, RC is statistically significant in models 5 and 7 only and has a negative sign, indicating that it provides a lower estimate of WTP compared to CVM (reference category). BT is not statistically significant across all models.

The variable PUB is negative in all models but statistically significant in model 5 only. The negative coefficient indicates that WTP reported in published papers provide smaller WTP as compared to unpublished papers (reference category).

With respect to model fit in the functional form-based models, the adjusted R^2 in model 5 explains 28% variation in the dataset. The adjusted R^2 in models 6, 7 and 8 explain 10%, 67%, and 64% variation in the dataset, respectively. It is clear that dropping one outlier observation sharply decreases the overall goodness-of-fit of model 6. It may be due to the small sample size in the dataset or the dropped observation has as a large influence on the data.

Models 5 and 6 are linear models, and were not used to calculate WTP in policy sites and validity tests. Although these models have more statistically significant coefficients, these two models have significantly lower adjusted- R^2 as compared to models 7 and 8. Hence out of eight models only two models were chosen for further analysis. The double log models (i.e., models 7 and 8) were used to estimate WTP in policy sites and to perform all validity tests as at this stage there is no a priori reason as to which model is better.

5.4. Validity Test Results

The results of the validity tests are given below. Table 11 presents the estimated WTP with outlier (model 7) and without outlier (model 8) and their corresponding transfer error (TE).

The reason for choosing models 7 & 8 was mentioned in validity testing procedure in the method section. It is important to note that 40 out of 42 observations have smaller estimated WTP compared to the original WTP (i.e., underestimated transfer error) in model 7. Similarly, 39 out of 41 observations have smaller estimated WTP compared to the original (i.e., underestimated transfer error) in model 8. Thus, it is clear that most WTP and transfer errors were underestimated, which further need to be adjusted. The validity tests enable us to compare the results between these two models and tells us which model is doing better (see Table 12).

Validity test # 1 Similarity between original and estimated WTP amounts (transfer error)

Table 11. Estimation of transfer error (percentage difference in study sites)

Study ID	Reference	Author reported WTP in \$ (2012) (n=42)	Publish-ed year	Estimated WTP in \$ (2012) Model 7	Transfer errors (n=42) Model 7	Estimated WTP in \$ (2012) Model 8	Transfer errors (n=41) Model 8
1a	Moeltner and Woodward	14.62	2006	8.89	39.22	4.52	69.07
1b	Moeltner and Woodward	14.62	2006	8.64	40.90	4.84	66.92
3	Klocek	10.38	2004	1.47	85.82	1.56	85.00
4	Danielson and Leitch	6,736.36	1986	7.29	99.89	22.24	99.67
5a	Dillman et al.	65.70	1993	22.94	65.08	31.09	52.67
5b	Dillman et al.	30.41	1993	22.94	24.57	23.59	22.41
5c	Dillman et al.	26.77	1993	22.94	14.31	23.59	11.86
5d	Dillman et al.	76.79	1993	19.51	74.59	23.59	69.27
6	Pate and Loomis	24,404.61	1997	190.13	99.22	426.67	98.25
7a	Bloomquist and Whitehead	45.37	1991	13.74	69.73	11.97	73.63

7b	Bloomquist and Whitehead	21.19	1991	15.49	26.89	17.27	18.50
7c	Bloomquist and Whitehead	69.16	1991	12.12	82.47	4.49	93.51
8	Poor	113.97	1999	472.95	314.98	587.57	415.55
9a	Mullarkey	794,579.12	1997	107.83	99.99		
9b	Mullarkey	8,137.23	1997	28.83	99.65	24.19	99.70
10	Roberts and Leitch	74.20	1997	27.79	62.55	20.66	72.16
11a	Gupta and Foster	695.70	1975	65.45	90.59	15.04	97.84
11b	Gupta and Foster	379.47	1975	70.39	81.45	15.88	95.82
11c	Gupta and Foster	421.63	1975	63.63	84.91	14.70	96.51
11d	Gupta and Foster	505.95	1975	68.12	86.54	15.56	96.92
11e	Gupta and Foster	516.50	1975	64.61	87.49	14.84	97.13
11f	Gupta and Foster	569.21	1975	63.54	88.84	14.84	97.39
11g	Gupta and Foster	590.28	1975	62.85	89.35	14.35	97.57
11h	Gupta and Foster	611.37	1975	61.76	89.90	13.94	97.72
11i	Gupta and Foster	664.08	1975	60.54	90.88	13.42	97.98
12	Stevens et al.	664.08	1995	247.51	62.73	80.72	87.84
13a	Hovde	11.24	1994	9.20	18.12	9.48	15.67
13b	Hovde	21.86	1994	8.14	62.74	9.27	57.58
13c	Hovde	5.48	1994	10.10	84.34	10.72	95.60
13d	Hovde	13.54	1994	9.00	33.55	9.23	31.86
14a	Loomis and Hanemann	15,618.08	1991	254.24	98.37	252.65	98.38
14b	Loomis and Hanemann	6,524.53	1991	310.72	95.24	301.57	95.38

15a	Creel and Loomis	331.45	1992	249.34	24.77	221.19	33.27
15b	Creel and Loomis	2,567.57	1992	206.90	91.94	181.64	92.93
15c	Creel and Loomis	1,924.01	1992	204.38	89.38	304.90	84.15
16	Whitehead	557.36	1991	3.15	99.44	110.50	80.17
17	Shabman and Batie	4,352.07	1987	30.37	99.30	7.96	99.82
18a	Cangelosi et al	65,464.34	2001	41.77	99.94	41.22	99.94
18b	Cangelosi et al	4,547.02	2001	86.22	98.10	92.57	97.96
19	Joworski and Raphel	951.39	1980	900.85	5.31	252.14	73.50
20	Mjelde & Machingambi	2,477.41	2012	280.14	88.69	380.32	84.65
21	MacDonald et al.	240.06	1998	3.98	98.34	2.50	98.96
	Mean	3,684.56		105.25	79.53	88.51	86.60

There is no thumb rule as to how much transfer error is acceptable. Several experts argue and use their subjective judgments and the methods employed to justify their analysis. Brouwer and Spaninks (1999) cite that Loomis et al. (1995) have as high as 475% transfer error. The overall mean transfer error of all study sites for model 7 is 79.53% and model 8 is 86.60%. The individual transfer is as large as 314.98% for model 7 and 415.55% for model 8, which is found in Northern Plains/Lake States region. The overall WTP mean of original study sites is \$3,684.56.

As previously mentioned, there were more underestimated transfer error (i.e., estimated WTP is less than original or author reported WTP) and only two observations have overestimated transfer error. In model 7, forty (40) observations have underestimated transfer error (5.31% to 99.99%) and two observations have overestimated transfer error (84.34% and 314.98%). Similarly, in model 8, thirty nine (39) observations have underestimated transfer error (11.86% to 99.94%)

and two observations have overestimated transfer error (95.60% and 415.55%). The ordinary least squares coefficients were obtained using the models described in method section. In doing so, one observation was dropped at a time when the regression equation was run (n=42).

Validity test # 2 Equality of original & estimated mean WTP values

Paired t-test was performed to examine the equality between author reported (original) WTP and estimated (projected) WTP. The paired t-test shows that the p-value (the smallest value that can reject null hypothesis) for model 7 is 0.243 and for model 8 it is 0.242, which are not statistically significant at or below 5% level. The equality of original and estimated WTP amounts requires that p value should be at or below 10% significance level. In our case, the equality of original and estimated WTP amounts for both models is not rejected and hence the validity is accepted.

Validity test # 3 Functional relationship (variability) between original & estimated WTP values

The functional relationship (variability) of original and estimated WTP amounts shows that these WTP values are similar and meet the criterion of convergence. This was obtained by a simple joint F test (i.e., restricted and unrestricted β_0 and β_1 coefficients) that examines if they are different from each other. The joint F-test result from model 7 shows that that:

$F_{2,39}=1.624 < F_{\text{critical}}=3.230$, which clearly indicates that the original WTP and estimated WTP are similar. The joint F-test result of the model 8 shows that: $F_{2,38}=1.243 < F_{\text{critical}}=3.232$, which indicates that the two WTPs are similar.

Validity test # 4 Correlation (Pearson's correlation) between original and estimated WTP

This test was performed using Pearson's correlation between original and estimated WTP amounts. The correlation between these WTP amounts obtained from model 7 is 0.004 (p-value=0.979) and from model 8 is 0.148 (p-value=0.356). Both models are not statistically significant at or below 10% level. These results indicate that there are weak correlation between

the author reported WTP values and estimated WTP values. This confirms that there is no apparent relationship between WTP values to support the validity or transferability.

The results of the validity tests of both models conclude that we cannot confirm which model is better over the other as both models passed three out of four tests or criteria (Table 12). Both models were rejected in validity test #4. Therefore, both models 7 & 8 are equally good in validity or transferability. The number of observations in model 7 is 42 (n=42) and model 8 is 41 (n=41). One outlier observation (i.e., 9a) has been excluded/dropped in model 8.

Table 12. Validity test results of study sites (n=41 & 42)

Test #	Validity test	Results		Validity (acceptance/rejection)	
		Model 7	Model 8	Model 7	Model 8
1	% difference between original WTP and estimated WTP or transfer error (TE)	Average transfer error: 79.53%	Average transfer error: 86.60%	Lower than Colombo & Hanley, 2008 (TE 680%) & Zanderson et al., 2007 (TE 194%) Acceptable	Lower than Colombo & Hanley, 2008 (TE 680%) & Zanderson et al., 2007 (TE 194%) Acceptable
2	Equality of original WTP & estimated WTP	p=0.243 (paired t-test)	p=0.242 (paired t-test)	Acceptable	Acceptable
3	Variability (or functional relationship) between original WTP & estimated WTP	Joint F-test ($F_{2,39}=1.624$) < $F_{2,39}$ critical=3.23	Joint F-test ($F_{2,38}=1.243$) < $F_{2,38}$ critical=3.23	Acceptable	Acceptable
4	Correlation (r) between original WTP & estimated WTP	Pearson's correlation (r) = 0.004 (p-value =0.979)	Pearson's correlation (r) = 0.148 (p-value =0.356)	Rejected	Rejected

5.5. Estimation of WTP for Policy Sites

To estimate WTP for the policy site wetlands, the coefficient estimates of models 7 and 8 (reduced log-log) were used. The results obtained using model 8 show that WTP in Mobile Delta/Fahkahatchee wetland located in Delta/Southern Plains had the highest WTP followed by human-made wetland located in Pacific region while the Henderson Slough wetland located in Appalachian region had the lowest WTP value. In model 7, human-made wetland had the highest estimated WTP followed by Troy and Great Piece Meadows. Just like model 8, Henderson Slough had the lowest the estimated WTP. Previous benefit transfer literature (Loomis et al. 1991) found that the Pacific region had relatively higher willingness-to-pay estimates for natural resources or outdoor recreation, which model 7 has shown. Comparing both models, the results show that WTP for Henderson Slough was approximately 2 times higher in model 8 compared to model 7. On the other hand, WTP from human-made wetland was approximately 2.5 times higher in model 7 compared to model 8.

Table 13. Estimated WTP values for policy sites

Study ID	Policy site wetland	Estimated WTP (US\$/ha.) Model 7	Estimated WTP (US\$/ha.) Model 8	ERS region
1	Troy and Great Piece Meadows	15.31	10.06	Northeast
2 & 3	Mobile Delta/Fahkahatchee strand	4.75	66.47	Southern Plains
4	Henderson Slough	0.82	1.63	Appalachia
5	Club House Slough	3.72	5.27	Northern Plains/Lake States
6	Human-made wetland	29.69	11.92	Pacific

The WTP values for policy sites were adjusted using average transfer error from study sites. This is done because the computed transfer errors were all underestimated with the exception of two observations in each model. The WTP_{adj} results are shown in Table 14. The adjusted WTP values for both models better reflect what the estimated values should have been for the six policy sites. Therefore, it is recommended that the estimated WTP from the benefit transfer model be adjusted to provide a more accurate value in wetland valuation research when TE calculations are predominantly under or over estimated.

Table 14. Adjusted WTP values for policy sites

Study ID	Policy site wetland	Adjusted WTP (WTP _{adj}) in US\$/ha. Model 7	Adjusted WTP (WTP _{adj}) in US\$/ha. Model 8
1	Troy and Great Piece Meadows	74.79	75.09
2 & 3	Mobile Delta/Fahkahatchee strand	23.21	496.07
4	Henderson Slough	4.02	12.17
5	Club House Slough	18.17	39.32
6	Human-made wetland	145.04	88.99

Based on the results of adjusted WTP calculations, Mobile Delta/Fahkahatchee wetland also resulted with the highest WTP value for model 8 and human-made wetland was also the highest for model 7. Henderson Slough remained the lowest WTP for both models. The highest adjusted WTP (Mobile Delta/Fahkatchee wetland) obtained in model 8 was approximately 21 times larger than the one obtained from model 7. The lowest adjusted WTP for both models (Henderson Slough) was more than 3 times larger in model 7 than in model 8. The adjusted WTP

values at policy site wetlands are considered reasonable or more accurate WTP values (see WTP values in study sites) in benefit transfer research (see Table 14).

CHAPTER SIX

DISCUSSION

This paper estimated eight empirical regression models for study sites and one model for policy sites. The base of all comparison is mean log of WTP in US dollars indexed 2012 unless otherwise noted. The reason for choosing year 2012 is that the latest benefit transfer study site was published in 2012 and this particular research was started in 2012, which makes this year a good base year for future studies. The variables that were investigated in these models include income, area, ERS regions, wetland types, valuation method used and publication types and were all hypothesized to influence WTP for biodiversity conservation in wetlands.

The INC and log.INC variables are statistically significant in 6 out of the 8 models. Most of the peer-reviewed literature found income as having a positive coefficient. However, the results of this research do not confirm this finding since INC variable has both positive and negative coefficients among the eight models. The changing sign of statistically significant INC variable (i.e., model 1) from positive to negative and not significant (i.e., model 2) is an issue in this research. The same is also true for the log.INC variable. The inconsistency of the sign of log.INC variable could be due to the omitted variables (wetland types), which were statistically significant in model 1. This could also indicate that the sample size is too small to make it more robust. Published articles in benefit transfer either have not included income variable such as Woodward & Wui (2001) or do not have multiple models so that the propensity of income variable could be seen.

In the variable-based approach, log.AREA was not significant in any of the models but the negative sign of this variable in the first three models provide interesting insights regarding the wetlands' production function. A better way to interpret the wetland area variable is by taking its

first order derivative form, which is the marginal rate of change of AREA as represented by equation 6.1. If we represent the dependent variable by y, then the marginal rate of change as shown by Woodward & Wui (2001) for double log model looks like the following-

$$\frac{\partial y}{\partial AREA} = \beta_0 \cdot AREA^{(\beta_0-1)} e^{(\beta_1 \cdot INC + \beta_2 \cdot NE + \beta_3 \cdot APPAL + \beta_4 \cdot MTN + \beta_5 \cdot NPLS + \beta_6 \cdot DSP + \beta_7 \cdot PAC + \beta_8 \cdot FRESH + \beta_9 \cdot SWAMP + \beta_{10} \cdot SWAMP + \beta_{11} \cdot PRAIRIE + \beta_{12} \cdot HEM + \beta_{13} \cdot LAC + \beta_{14} \cdot COAST + \beta_{15} \cdot CVM + \beta_{16} \cdot RC + \beta_{17} \cdot BT + \beta_{18} \cdot YEAR)} \quad (6.1)$$

Where β_i are estimated coefficients, e is natural log, and all capitalized letters are independent variables.

In models 1, 2, and 3, the effect of wetland area shows decreasing returns to scale (DRS). In production economics, this means increasing inputs results to a less than proportional increase in outputs. For example, looking at model 1, if we increase wetland size by 100 hectares, WTP will decline by 0.03%. Because the model has double log functional form, the effect will be very small in the case of larger wetland (Woodward & Wui, 2001). Model 4 has a positive coefficient indicating increasing returns to scale (IRS) This means that adding additional input (i.e., wetland area) results to a more than proportional increase in output (i.e., WTP).

The AREA variable only has a significant coefficient when models take a linear form (e.g., models 5 and 6). Under model 5, wetland area exhibits decreasing returns to scale while model 6 shows area as exhibiting increasing returns to scale.

The YEAR variable has a negative coefficient in 7 out of 8 models and is not statistically significant except in model 5. Woodward & Wui (2001) found this variable to be not significant in their study.

Since FRESH has consistently positive sign across models (when it is statistically significant), this indicates that WTP values from the FRESH wetland are higher compared to

PRAIRIE (reference category) wetlands. COAST also has positive sign with statistically significant in some models, which means COAST wetland provides higher WTP values than the PRAIRIE (reference category) wetland. These two wetland types (FRESH & COAST) are very important in explaining WTP values and are consistent with many research findings (Shabman & Batie, 1987; Pate & Loomis, 1997) while the other wetland type variables are not significant in explaining WTP values.

With respect to variables representing ERS regions or locational variables, the coefficients of NE, APPAL, MTN, and SE show mixed results (i.e., positive and negative signs) in the models where they are significant (see tables 9 and 10). DSP and NPLS were consistently positive when they are significant. The mean WTP of Pacific region is the highest among all ERS regions (see table 8) and is supported by existing literature (Loomis, 1992). These studies attested that people are willing to pay more for wetlands conservation in this region. This is not the case in the meta-regression analyses from this research. For example, the Delta/Southern Plains and Northern Plains/Lake States have positive coefficients in the models where these variables were significant, which indicate that these ERS regions give higher WTP values as compared to the Pacific or PAC region (reference category). However, just like the findings from this research, other studies reported higher WTP for the Delta region (e.g., Shabman & Batie, 1987), which has coastal wetlands.

With regards to variables representing valuation methods, the meta-regression results show that the RC variable is negative and statistically significant among six models, which suggests that WTP estimate using this method is lower than WTP from CVM (reference category). Previous authors also reported lower WTP calculations using RC method (e.g., Gupta & Foster, 1975; Hovde, 1994). The results also show that while BT was not significant, its negative sign in

most of the models indicate that WTP from this method is lower relative to CVM. Woodward & Wui (2001) stated that CVM usually overestimates than other common environmental valuation methods as it is associated with hypothetical questions and not actually requires people to pay.

Regarding the YEAR variable, it was only significant in model 5. However, some interesting facts were obtained on valuation trend based on year. The wetland valuation studies conducted in 1996-2005 had been estimated with higher WTP values than any of the other three study periods (1975-1985, 1986-1995, and 2006-2012) and the a decreasing trend can also be observed from this study.. There is no apparent reason to explain why this is the case in non-market valuation , yet during 1996 to 2005 there was a boom in benefit transfer studies in the United States and in Europe.

The R^2 and adjusted- R^2 of model 6 were 46.2% and 10.3%, respectively, which indicates that the goodness of fit drops sharply when one outlier was dropped from the analysis. It may be due to the absence of influence of an outlier observation because it was dropped in model 6. The R^2 and adjusted- R^2 were 80.5% and 66.6% in model 7 (or model 1), respectively. This indicates that this model maintained stability on the overall goodness-of-fit. If we compare models 7 and 8, there is no sharp difference between the two models in terms of model's fitness. Dropping PUB variable (i.e., model 3) does not affect the model's overall explanatory power because the full model in both approaches have almost the same R^2 and adjusted- R^2 . Therefore PUB does not have a big impact on the model. In other words, there is not much difference to include PUB in the model.

The selection of empirical models for further analyses was done on the basis of adjusted- R^2 . The adjusted- R^2 of model 7 (or model 1) was the largest among the eight regression models. Model 8 is simply an extension of model 7 with one identified outlier, which has third largest

adjusted- R^2 . The model with the second largest adjusted- R^2 (model 3) did not include the PUB variable and was not considered for further analysis. This is because another criterion used for selecting the models to be used for further analyses was that the selected model(s) should have all the independent variables (i.e., without dropped variables).

The estimated willingness-to-pay for wetland conservation in policy sites using models 7 and 8 seems to be consistent with results from previous literatures. Results obtained from model 7 show that WTP of human-made wetland in the Pacific region had the highest WTP of any of the policy sites. However, Mobile Delta/Fahkatchee wetlands located in the Southern Plains had the highest WTP value among the selected policy sites if we consider model. Literature (e.g., Cooper & Loomis, 1992; Creel & Loomis, 1992) often notes that wetlands in the Pacific region have higher WTP than other regions. The findings from this study is partially consistent with the findings from these other studies. The Henderson Slough located in the Appalachian region had the lowest WTP in both models. This result is consistent with the results reported by Kloeck in his dissertation (2004), which is around \$9.00. The WTP values at policy sites were compared with reported WTP values in previous studies done by Kloeck (2004), Whitehead and Bloomquist (1991) and Gupta & Foster (1975) and they were fairly consistent. The adjusted WTP values in policy sites (WTP_{adj}) show that models 7 & 8 are consistent with the WTP values reported by previous authors from year 1975 to 2012 (see appendix 3).

Validity tests were conducted to examine the potential for transferability of the results obtained in this study to benefit transfer research. Shrestha & Loomis (2003), Brouwer et al. (1999), Bateman et al. (2000), and Lindhjem & Navrud (2008) were the only authors who have done validity testing of WTP estimates from benefit transfer approach. The validity test suggested by Shrestha and Loomis (2003) was adopted in this research.

In validity test # 1, the average transfer error of model 7 was smaller than model 8, which tells us that model 7 is performing slightly better than model 8. The minimum and maximum range of transfer error or percentage error found in the analysis ranged from |5.31%| to 314.98% in model 7 and |11.86%| to 415.55% in model 8, which is within the limit reported in most of the literature. For example, Loomis et al. (1995) had estimated as high as 475% transfer error. Colombo & Hanley (2005) in farmland research found an average transfer error of 680% with upper bound transfer error 7,496%. There is no clear boundary on how much transfer error is acceptable and therefore authors attempt to justify their transfer errors are acceptable unless there are critical economic and scientific issues. Economists have agreed that small transfer error is preferable for efficient benefit transfer. As noted by Rosenberger & Phipps (2007), site correspondence or similarity could be one of the dominant factors in obtaining smaller percentage of error (i.e., transfer error). The main concern in benefit transfer research is to reduce transfer error since the successful transfer is associated with the acceptance and rejection of the validity test. It is recommended that increasing the sample size may provide relatively smaller transfer error. The use of Bayesian econometric model may be one of the good choices to obtain more accurate WTP estimates and corresponding transfer errors.

Results of validity test # 2 did not reject ($p\text{-value} > 0.10$) the validity of transferring WTP values to other sites. In order to obtain equality between original and estimated WTP, the paired t-test requires that it should not reject the null hypothesis (see validity testing in method section). The results show that the p-values in models 7 and 8 indicate that the null hypothesis cannot be rejected at or below 10% significant level. This result confirms that the original and estimated WTP amounts are converging to each other both in models 7 and 8. Shrestha & Loomis (2003)

were the only authors who have done this validity tests in the USA. In their case, they failed to get convergence between the original and estimated WTP.

Validity test #3 considers the functional relationship between the two different WTP amounts. This test requires that the intercept or constant (β_0) is close to zero and the coefficient estimate (β_1) of estimated WTP is close to one. This means that there is no variability (functional relationship) between original and estimated WTP (see validity test #3 in method section). Results of the joint F-test in models 7 and 8 indicate that we failed to reject the null hypothesis and thus transferability of WTP estimates is possible. Therefore, this validity test is acceptable for both models. This test result is consistent with the test found by Shrestha & Loomis (2003) in their benefit transfer study.

Validity test #4 rejects the transferability of WTP estimates from this study. This is because there was no significant correlation between original and estimated WTP in models 7 and 8. The weak correlation observed is not robust to support the validity. Therefore, this validity test is rejected for both models 7 & 8. Shrestha & Loomis (2003) found a higher correlation (i.e., 0.651) between the original and estimated WTP values of outdoor recreation at the national level but a lower (i.e., 0.191) and not statistical significant at the regional level. To improve the correlation between original and estimated WTP amounts, sample size may be increased and some socio-economic variables such as education, gender, and the distance from the wetlands may be included in the models.

One of the major concerns in this research s are the results obtained in the validity tests. Models 7 & 8 have passed the first three tests but failed to pass validity test #4. Validity test #1 is a simple test of differences between original and estimated WTP values. Validity tests 2 & 3 are less strong in their assessments regarding the transferability of the model estimates. That is, the

null hypothesis of these two tests are not stringent, which make their statistical confidence interval bigger. If the confidence interval is bigger, then it is not difficult for the estimated WTP values to fall within the big intervals. However, the null hypothesis proposed in validity test #4 is the upper bound of Pearson's correlation ($r=0$) and therefore has a smaller confidence interval. Our assumption was that hypothesizing the null hypothesis ($r=0$) may not be meaningful since any correlation with lower bound could pass this stringent validity test. Therefore this test with upper bound & statistical significance was set so that any lower correlation and insignificant results cannot pass this validity. The results indicate that this test were rejected for both models 7 and 8 and also statistically not significant in both models.

The adjusted WTP at policy sites are particularly important because the computed transfer errors are predominantly underestimated at the study sites, so adjusted WTP are expected to be higher than unadjusted values. The adjusted WTP values at the six policy sites (WTP_{adj}) provide better WTP estimates in both models 7 and 8 because the adjustments account for the predominant underestimation of transfer error and overcomes the rejection of validity test # 4 (i.e., correlation). Therefore, the adjusted WTP in these policy sites provide a more accurate value in wetland valuation research. This is one of the new techniques proposed when transfer errors are predominantly under or over estimated.

From Table 14, the adjusted WTP for human-made wetland is large in model 7 than the rest of the policy site wetlands. The reason may be due to higher household income in this region. The adjusted WTP for Mobile Delta/Fahkatchee wetland is much larger in model 8 than any other policy sites. It is due to the very large area (i.e., wetland size), which is one of the major variables in this analysis. Adjusted WTP of the policy site wetlands are quite small compared to Mobile Delta/Fahkatchee wetland.

The validity test results confirm that both models 7 and 8 are performing competitively. Both models passed three out of four validity criteria but were rejected in fourth test or criterion. Therefore validity tests cannot tell much which model is doing better. At this point, both models 7 and 8 are recommended for future wetland valuation research. Further, estimated WTP values at policy sites were adjusted and they represent more reasonable and more accurate WTP values in both models 7 and 8. This is a novel approach in the case of underestimation or overestimation of transfer error as this approach adjusts TE.

It is important to note that willingness-to-pay for wetlands' biodiversity is considered as community/habitat function of wetland (Richardson, 1994). As mentioned in literature, willingness-to-pay for biodiversity is often determined by asking hypothetical questions of passive use where users/respondents do not get direct and immediate user experience. Therefore, the term biodiversity has not been mentioned in model development since it is our assumption throughout this entire research that willingness-to-pay represents the people's readiness to conserve wetlands' biodiversity. Previous peer-reviewed articles published in biodiversity were not empirical research in benefit transfer.

This research has employed all the recommended validity tests in benefit transfer research, estimated WTP at policy sites, and adjusted these estimated WTP. Such tests and procedures have not yet been conducted thoroughly in any paper especially in benefit transfer of natural resources such as wetlands. This is the first study that attempts to make adjustments of WTP estimates and may be quite helpful for future wetland research. Transfer error is unavoidable in benefit transfer research, therefore adjustments of WTP values at policy sites provide ample reasons for getting better WTP estimates.

The analyses were possible only when the data used are reported in same units or scales. In meta-analysis, studies or analyses are often collected from wide range of sources. This leads to obtaining data and information with varying degree of scales, units, and dimensions. Therefore the scale or unit adjustments should be done beforehand. In this research, inconsistency in units and scales obtained in meta-analysis required conversion of AREA into hectare. Similarly, INCOME was converted into US \$ 2012 index year to obtain analysis in comparable form, and YEAR was treated as ordinal variable for the research published year. Categorical variables were not converted as they are binary or qualitative variables.

CHAPTER SEVEN

CONCLUSIONS

Benefit transfer is a second best approach in environmental resources valuation when primary research (e.g., primary data collection) is difficult due to limited time and budget. The application of benefit transfer is rapidly increasing because of the advantages associated with it. The application of Weak Structural Utility Theoretic of meta-analysis protocol is one of the reasons of wider application of benefit transfer where the researcher can control the methodological differences and use meta-analysis to estimate benefit function to account commonalities in chosen study sites and proposed policy sites.

The application of the concept of meta-analysis and benefit transfer is rapidly increasing over the last four decades. This approach was largely used in studies involving several ecosystem services rather than standalone ecosystem services. A great opportunity exists in transferring benefit estimates to other areas of ecological inquiry such as estimating damages due to storms, oil spill, and conservation of natural resources to help policymakers in their decision for assessing damages and impact on economy. Yet, conducting primary research is the best way to get precise outcomes if there are plenty of time, budget, and manpower available.

Literatures in wetland valuation studies lack the economic criteria, meta-analysis and benefit transfer protocol suggested by Desvousges et al. (1992) and Bergstrom & Taylor (2006). Literatures that do not follow the recommendations or protocols for benefit transfer research were likely to be rejected in peer-reviewed publications. Many of the unpublished research reports lack details, contain poor econometric tools, lack documentation of dataset, and significantly missing meta-analysis protocol.

The original (author reported) and estimated (projected) WTP amounts in study sites do not vary much after adjustments which tells us that adjusted WTP could provide better estimates when the transfer errors are underestimated. The WTP amounts in policy sites are more or less similar for both models.

WTP values calculated at policy sites are consistent or even better with the author reported WTP values. Both models 7 and 8 are performing better with reasonable or accurate WTP values at selected policy sites after adjustments were made. The adjustment was done due to the rejection of the more stringent validity test (i.e., test #4). The estimated WTP values were adjusted using the average transfer error of models 7 and 8 of study sites. The economic reason of underestimation of transfer error is not clear, however, lower estimated WTP of study sites compared to original authors is one of the reasons of underestimated transfer error (negative error).

A novel idea of adjusting WTP values at policy sites has been introduced in this research, which is the first application in the entire benefit transfer research of wetland valuation. The reason for introducing the adjusted WTP at policy sites is to account for the underestimated transfer errors and the not so strong results of validity tests (i.e., validity test #4 failed) as well to provide more accurate and better WTP values.

Results obtained in the validity tests suggest that both model 7 and 8 are performing well since both of these models pass three out of four validity tests. Results indicate that the outlier observation included in model 7 may not have largely influenced or skewed the results in our case. However, researchers should pay attention on taking more outlier observations when the sample size is small.

During the literature review, it was found that none of the authors have followed the comprehensive and scientific wetland classification developed by Cowardin et al. (1979) in their

wetland valuation studies. Cowardin classification is one of the most widely accepted wetland classification not only in the United States but all over the world. The wetland valuation literature have randomly named wetlands by many authors, which does not follow scientific criteria making the research inconsistent from the beginning of benefit transfer. Addressing the wetland classification issue in all research papers will help the readers, policy makers, and implementing agencies in redirecting their resources where there is a need. Therefore, it is quite important to conduct wetland research that incorporate ecological, economic, geographical, and social aspect so that it will be more credible. In this research, study sites and policy sites fall under palustrine system with emergent, forested wetland, and scrub shrub wetland classes. There is one lacustrine system of wetland with littoral class in the study sites.

As a universal rule in statistics, increasing the number of observations in such research will help in obtaining higher statistical power and thus stronger and more accurate results in wetland valuation. Perhaps it is better to capture more wetlands that provide multiple services. Doing this may be one of the best ways to obtain maximum number of wetland sites in the United States. In the case of this study, only a single wetland service (i.e., biodiversity which is a passive use) was chosen, which dramatically reduced the number of study sites and also the geographical coverage. Therefore, it is highly recommended to either select multiple services of wetlands or expanding the geographical coverage to obtain larger sample size for statistical analysis.

Another way to deal with small sample size is to use Bayesian model. Moeltner & Woodward (2007) used Bayesian modeling to get better WTP estimates for their two policy sites conducted in Nevada river basin with 9 observations. They suggested that even if an analyst has small size ($n < 30$), s/he can apply robust econometric tool such as Bayesian modeling that helps in obtaining robust WTP estimates suggested by Moeltner et al., 2007.

According to Woodward & Wui (2001), benefit transfer is an imprecise valuation in environmental economics. This is because this approach relies heavily on previous econometric analysis, data, economic theory, and any conclusion drawn by author(s) will be largely dependent on original research works. Provision of clear and substantial documentation of data is important to improve the existing pattern of analysis.

The results of the empirical models show that YEAR and PUB are less important variables when it comes to predicting WTP values of wetlands. On the other hand, household income (INC), wetland types, locational region are important variables explaining the WTP values. Therefore, it is recommended that inclusion of these variables in model(s) will improve WTP values in policy site wetlands. However, a researcher may include all of the variables they want to include in their models if the chosen econometric methods are robust such as Bayesian modeling and partitioning of data at different levels.

Future research should include additional variables of education, gender, age of users/nonusers, race, season, and distance of wetland from residence in regression models. These variables may help in obtaining more accurate and reliable WTP values. These variables may influence values for wetland conservation because of the fact that wetland is a public good. It is hard to find literature which has such variables in their models and analysis. The issue of sample size may be solved by the inclusion of wetland sites from around the world but subject to questions about the reliability of data, collection methods, empirical analysis, and quality of final paper to get accepted for publication.

In addition to demographic variables, future research should include variables that would clearly explain the biodiversity. In this research, multivariate regression models were used, except for region and wetland type, there were not enough biodiversity variables available from the

wetland valuation literature. Wetland diversity value estimation would be improved with the inclusion of preferences variables (active vs. passive uses), context variables (GDP), and ecological variables (species and richness/density). Inclusion of such variables will be helpful to obtain more precise estimates on biodiversity of wetland. For this purpose, meta-analysis can be used for collecting and compiling ecological and monetary variables. Future research needs to include measurements of variables that represent biodiversity in wetlands.

Based on available literature in wetland valuation in the United States, there is not enough information available to address valuation of other wetlands in the U.S. Increasing wetland valuation literature will help in creating awareness among the public regarding the economic trade-offs of wetland destruction. This enhanced knowledge among the general public on economic benefits of wetlands will be an instrumental tool in wetland conservation in the future.

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NOTE:

Acquisition means acquiring potential tract of wetlands that is important to conserve biodiversity.

Biodiversity encompasses three major components: ecosystem diversity, species diversity, and genetic diversity. This study is focused on species and ecosystem conservation and there are no or rare literature in wetland genetic study, therefore genetic diversity is excluded from this study.

Benefits/Net Willingness to Pay/Consumer Surplus Economic benefits or willingness to pay (WTP) is defined as the maximum amount the user (e.g., visitor, household) would pay to continue to have access to a given natural resource or for an improvement in the natural resource (e.g., increase in size of a national wildlife refuge). Willingness to pay minus the actual cost to use the resource (e.g., entrance fee or transportation cost) yields the net willingness to pay which is also known as consumer surplus. This measure of net benefits is appropriate for evaluating the net gain to visitors or residents of an area or to society as a whole from land acquisition or habitat improvement (adapted from Economics for the Environment Consultancy report, 2010, the UK).

Appendix 1. Typical Benefit Transfer Procedure

Appendix 2. Wetlands Distribution in the Contiguous United States (with Policy Sites)

Source: www.untamedScience.com

Appendix 3. Study Sites

Study ID	Reference	Author(s)	Published year	WTP/ha(\$)	Area (ha.)	Income (\$)	Wetland type	Method	ERS region
1a	Shoshone Pond Natural Area	Moeltner and Woodward	2006	14.62	501.704	56,361	Freshwater	CVM	Mountain
1b	Swamp Cedar Natural Area	Moeltner and Woodward	2006	14.62	1,294.72	56,361	Freshwater	CVM	Mountain
2	Alfred peat bog, Canada (deleted)	Tkac	2002	14.69	4,198.00	58,328	Swamp	CVM	Pacific
3	Cannan valley wetlands	L Kloczek	2004	8.17	9,423.90	40,196	High elev. moist	CVM	Appalachian
4	Prairie wetlands in west central MN (Lake State)	Danielson and Leitch	1986	6,736.34	335,591.42	58,906	Prairie pothole	CVM	Northern Plains
5a	Francis Bielder Forest, SC	Dillman et al.	1993	65.7	1,011.5	43,107	Freshwater	CVM	Southeast
5b	Francis Bielder Forest, SC	Dillman et al.	1993	65.7	1,011.5	43,107	Freshwater	CVM	Southeast
5c	Francis Bielder Forest, SC	Dillman et al.	1993	65.7	1,011.5	43,107	Freshwater	CVM	Southeast
5d	Francis Bielder Forest, SC	Dillman et al.	1993	65.7	1,011.5	43,107	Freshwater	CVM	Southeast
6	San Joaquin wetlands	Pate and Loomis	1997	24,404.61	50,575	58,328	Freshwater	CVM	Pacific
7a	Various wetland habitats	Bloomquist and Whitehead	1991	45.38	1,605.45	41,724	Swamp	CVM	Appalachian
7b	Various wetland habitats	Bloomquist and Whitehead	1991	21.19	28,354.368	41,724	Swamp	CVM	Appalachian
7c	Various wetland habitats	Bloomquist and Whitehead	1991	69.16	10,202.394	41,724	Swamp	CVM	Appalachian
8	Rainwater Basin wetlands	Poor, J.	1999	116.5	6,473.6	50,723	Freshwater	CVM	Northern Plains
9a	US highway 53 wetlands (Lake State)	Mullarkey, D.	1997	794,579.12	44.506	51,059	Freshwater	CVM	Northern Plains
9b	US highway 53 wetlands (created wetland) Lake State	Mullarkey, D.	1997	135,619.01	89.012	51,059	Freshwater	RC	Northern Plains
10	Mud lake wetland area	Roberts and Leitch	1997	74.2	2,023	53,585	Lacustrine	CVM	Northern Plains
11a	White Cedar Bog	Gupta and Foster	1975	695.7	7.49	65,339	Freshwater	RC	Northeast
11b	Otis Fresh Marsh	Gupta and Foster	1975	379.47	3.00	65,339	Freshwater	RC	Northeast
11c	Bear Meadow	Gupta and Foster	1975	421.63	99.19	65,339	Freshwater	RC	Northeast
11d	Hyannis Wooded Swamp	Gupta and Foster	1975	505.96	2.00	65,339	Freshwater	RC	Northeast
11e	Moore's Pond	Gupta and Foster	1975	516.5	22.29	65,339	Freshwater	RC	Northeast
11f	Chicopee River Marshes	Gupta and Foster	1975	569.21	50.71	65,339	Freshwater	RC	Northeast
11g	Hoosic River	Gupta and Foster	1975	590.29	109.43	65,339	Freshwater	RC	Northeast
11h	Lawrence Swamp	Gupta and Foster	1975	611.37	379.88	65,339	Freshwater	RC	Northeast
11i	Wenham Swamp	Gupta and Foster	1975	664.07	906.60	65,339	Freshwater	RC	Northeast
12	General wetlands in New England	Stevens et al.	1995	425.29	3,236.8	65,339	Freshwater	CVM	Northeast
13a	Nome wetland	Hovde	1994	11.54	1.2138	53,585	Prairie pothole	RC	Northern Plains
13b	Buchanan wetland	Hovde	1994	22.4	6.8782	53,585	Prairie pothole	RC	Northern Plains
13c	Alice wetland	Hovde	1994	5.61	3.2368	53,585	Prairie pothole	RC	Northern Plains
13d	Tower City wetland	Hovde	1994	13.89	1.6184	53,585	Prairie pothole	RC	Northern Plains
14a	San Joaquin wetlands	Loomis and Hanemann	1991	15,618.07	23,466.8	58,328	Freshwater	CVM	Pacific

14b	San Joaquin wetlands	Loomis and Hanemann	1991	6524.53	16,184	58,328	Freshwater	CVM	Pacific
15a	San Joaquin wetlands	Creel and Loomis	1992	331.45	34,391	58,328	Freshwater	CVM	Pacific
15b	San Joaquin wetlands	Creel and Loomis	1992	1,568.31	34,391	58,328	Freshwater	CVM	Pacific
15c	San Joaquin wetlands	Creel and Loomis	1992	1,924.01	34,391	58,328	Freshwater	CVM	Pacific
16	Clear Creek wetland area	Whitehead	1991	225.65	2,023	41,724	Freshwater	CVM	Appalachian
17	Louisiana coastal marsh	Shabman and Batie	1987	4,352.08	21,939.43	42,944	Coastal	CVM	Delta
18a	Saginaw bay, Michigan (Lake State)	Cangelosi et al.	2001	65,464.34	18,215.90	46,859	Freshwater	CVM	Northern Plains
18b	Saginaw bay, Michigan (Lake State)	Cangelosi et al.	2001	4,547.02	17,608.19	46,859	Freshwater	CVM	Northern Plains
19	Great Lake Coastal wetlands (lake St)	Jaworski and Raphel	1980	951.39	42,828.93	46,859	Coastal	RC	Northern Plains
20	George W. Shannon wetland (Southern Plains)	Mjelde & Machingambi	2012	2,477.41	101.15	50,740	Freshwater	BT	Delta
21	Little River/Rooty Creek	MacDonald et al.	1998	240.06	133.51	47,209	Freshwater	CVM	Southeast

CVM Contingent Valuation Method

RC Replacement Cost

BT Benefit Transfer

ERS Economic Research Service

ERS regions are based on United States Department of Agriculture, An Economic Research Service classification, 2007

All monetary figures are in 2012 US dollars

Conversion of wetland area was done by using 1 hectare = 2.47 acres

Appendix 4. Policy Sites

1. Natural Wetlands

Wetlands	Area (acres)	Coverage	State	Population (CBS, 2010)	ERS region
Troy and Great Piece	5,300	Essex & Morris counties	New Jersey	1,276,922	Northeast
Mobile delta	65,000	Mobile & Baldwin	Alabama	596,472	Southeast
Fahkahatchee	75,000	Collier	Florida	322,472	Southeast
Henderson slough	5,000	Henderson & Union	Kentucky	61,307	Appalachian
Club House slough	16,000	Roberts (SD) & Traverse (MN)	South Dakota & Minnesota	13,735	Northern plains and lake states

Population breakdown

Essex county	784,228
Morris county	492,694
Mobile county	413,277
Baldwin county	183,195
Collier county	322,472
Henderson county	46,302
Union county	15,005
Roberts county	10,193
Traverse county	3,542

Source: US Census, population estimate (July 2010)

[<http://www.census.gov/popest/data/intercensal/county/CO-EST00INT-01.html>]

2. Constructed wetlands

Wetlands	Area (acres)	Coverage	State	Population (CBS, 2010)	ERS region
Human made (Mullarkey)	220	Wisconsin	Wisconsin	60,070	Lake states
Human made (Gersberg et al.)	1.90	Santee	California	53,413	Pacific

Appendix 5. OLS Regression Coefficients Dropping One Observation (Model 7)

Dropp- ed id	CON S	YEA R	PU B	RC	BT	FRE SH	SWA MP	HEM	LAC	COA ST	NE	APP AL	MT N	DSP	NPLS	SE	Log.A REA	Log.INC
ID 21	-98.27 (46.74) **	-0.08 (0.03) **	-0.98 (0.43) **	-1.49 (0.63) **	-1.20 (1.34)	3.24 (0.65)** *	1.19 (0.85)	1.13 (1.19)	-0.80 (0.79)	1.63 (1.23)	-1.02 (0.80)	2.20 (1.57)	-0.05 (0.99)	4.49 (1.59) ***	2.93 (0.79)** *	0.65 (1.40)	0.10 (0.16)	21.01 (9.69)**
ID 20	-109.51 (50.50) **	-0.06 (0.04)	-0.39 (0.38)	-1.42 (0.68) **	-	3.27 (0.70)** *	1.15 (0.93)	1.53 (1.28)	-0.44 (0.84)	2.52 (1.27)*	-1.47 (0.84) *	2.21 (1.71)	0.11 (1.08)	3.82 (1.70) **	2.85 (0.85)** *	1.41 (1.48)	-0.03 (0.17)	23.34 (10.47)**
ID 19	-109.51 (50.50) **	-0.06 (0.04)	-0.06 (0.38)	-1.42 (0.68) **	2.58 (1.13) **	3.27 (0.70)** *	1.15 (0.93)	1.53 (1.28)	-0.44 (0.84)	6.34 (2.15)** *	-1.47 (0.84) *	2.21 (1.71)	0.11 (1.08)	omitted	2.85 (0.85)** *	1.41 (1.48)	-0.03 (0.17)	23.34 (10.47)**
ID 18b	-115.25 (56.60) **	-0.06 (0.04)	-0.40 (0.39)	-1.42 (0.70) **	-1.26 (1.49)	3.30 (0.73)** *	1.11 (0.96)	1.52 (1.31)	-0.43 (0.86)	2.62 (1.36)*	-1.53 (0.89) *	2.38 (1.88)	0.19 (1.15)	3.92 (1.78) **	2.89 (0.89)** *	1.56 (1.63)	-0.04 (0.17)	24.54 (11.76)**
ID 18a	-167.03 (48.77) ***	-0.06 (0.03) *	-0.52 (0.34)	-1.44 (0.80) **	-1.51 (1.28)	3.57 (0.62)** *	0.76 (0.83)	1.38 (1.13)	-0.27 (0.74)	3.51 (1.17)** *	-2.11 (0.77) ***	3.95 (1.62) **	0.98 (0.99)	4.80 (1.53) ***	3.25 (0.76)** *	2.89 (1.40) **	-0.10 (0.15)	35.43 (10.14)***
ID 17	-109.51 (50.50) **	-0.06 (0.04)	-0.39 (0.38)	-1.42 (0.68) **	-	3.27 (0.70)** *	1.15 (0.93)	1.53 (1.28)	-0.44 (0.84)	2.52 (1.27)*	-1.47 (0.84) *	2.21 (1.71)	0.11 (1.08)	2.58 (1.13) **	2.85 (0.85)** *	1.41 (1.48)	-0.03 (0.17)	23.34 (10.47)**
ID 16	-109.51 (50.50) **	-0.06 (0.04)	-0.39 (0.38)	-1.42 (0.68) **	-1.23 (1.45)	3.27 (0.70)** *	3.36 (1.56)**	3.74 (1.92)*	-0.44 (0.84)	2.52 (1.27)*	-1.47 (0.84)	-	0.11 (1.08)	3.82 (1.70) **	2.85 (0.85)** *	1.41 (1.48)	-0.03 (0.17)	23.34 (10.47)**
ID 15c	-109.23 (51.97) **	-0.06 (0.04)	-0.38 (0.40)	-1.42 (0.70) **	-1.23 (1.49)	3.27 (0.72)** *	1.15 (0.95)	1.54 (1.31)	-0.44 (0.86)	2.52 (1.30)*	-1.48 (0.87) *	2.19 (1.78)	0.10 (1.11)	3.80 (1.77) **	2.84 (0.90)** *	1.40 (1.54)	-0.03 (0.17)	23.28 (10.77)**
ID 15b	-108.27 (51.93) **	-0.06 (0.04)	-0.37 (0.40)	-1.42 (0.70) **	-1.21 (1.49)	3.26 (0.72)** *	1.15 (0.95)	1.55 (1.31)	-0.44 (0.86)	2.50 (1.30)*	-1.50 (0.87) *	2.14 (1.78)	0.07 (1.11)	3.75 (1.76) **	2.81 (0.90)** *	1.36 (1.54)	-0.03 (0.17)	23.09 (10.76)**
ID 15a	-101.12 (49.97) *	-0.06 (0.03)	-0.28 (0.38)	-1.41 (0.67) **	-1.08 (1.43)	3.19 (0.69)** *	1.18 (0.91)	1.65 (1.26)	-0.40 (0.82)	2.43 (1.25)*	1.74 (1.71) *	1.74 (1.71)	-0.12 (1.07)	3.38 (1.70) *	2.56 (0.86)** *	1.05 (1.48)	-0.04 (0.16)	21.64 (10.36)**
ID 14b	-110.21 (52.26) **	-0.06 (0.04)	-0.37 (0.42)	-1.41 (0.71) **	-1.24 (1.49)	3.28 (0.72)** *	1.15 (0.95)	1.54 (1.31)	-0.43 (0.86)	2.54 (1.32)*	-1.47 (0.86) *	2.24 (1.77)	0.13 (1.15)	3.83 (1.74) **	2.87 (0.90)** *	1.45 (1.57)	-0.03 (0.17)	23.48 (10.83)**
ID 14a	-116.27 (51.59) **	-0.06 (0.04)	-0.25 (0.42)	-1.35 (0.70) *	-1.30 (1.47)	3.32 (0.71)** *	1.12 (0.94)	1.64 (1.30)	-0.34 (0.85)	2.71 (1.30)**	-1.51 (0.85) *	2.46 (1.75)	0.36 (1.13)	3.94 (1.72) **	3.01 (0.88)** *	1.74 (1.55)	-0.05 (0.17)	24.70 (10.69)**
ID 13d	-109.22 (51.75) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) **	-1.23 (1.48)	3.26 (0.74)** *	1.14 (0.95)	1.52 (1.32)	-0.45 (0.86)	2.51 (1.30)*	-1.47 (0.86) *	2.20 (1.75)	0.10 (1.11)	3.81 (1.74) **	2.84 (0.88)** *	1.40 (1.52)	-0.03 (0.17)	23.28 (10.73)**
ID 13c	-106.31 (51.20) **	-0.06 (0.04)	-0.40 (0.38)	-1.38 (0.69) *	-1.26 (1.47)	3.15 (0.73)** *	1.07 (0.94)	1.38 (1.31)	-0.54 (0.86)	2.40 (1.30)*	-1.44 (0.85) *	2.12 (1.73)	0.00 (1.09)	3.74 (1.72) **	2.77 (0.87)** *	1.31 (1.50)	-0.04 (0.17)	23.67 (10.61)
ID 13b	-111.08 (51.69) **	-0.06 (0.04)	-0.38 (0.39)	-1.45 (0.71) **	-1.21 (1.48)	3.33 (0.74)** *	1.19 (0.95)	1.62 (1.33)	-0.40 (0.86)	2.59 (1.32)*	-1.49 (0.86) *	2.25 (1.74)	0.16 (1.11)	3.84 (1.73) **	2.89 (0.88)** *	1.45 (1.52)	-0.04 (0.17)	23.66 (10.72)**
ID 13a	-108.63 (51.70) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) **	-1.23 (1.48)	3.23 (0.73)** *	1.13 (0.95)	1.50 (1.32)	-0.47 (0.86)	2.50 (1.30)*	-1.47 (0.86) *	2.18 (1.75)	0.08 (1.11)	3.78 (1.74) **	2.82 (0.87)** *	1.38 (1.52)	-0.04 (0.17)	23.16 (10.72)**
ID 12	-126.59 (51.75) **	0.04 (0.09)	-0.79 (0.49)	-1.91 (0.78) **	-1.77 (1.50)	2.50 (0.93)** *	0.14 (1.22)	-1.08 (2.44)	-1.49 (1.18)	3.77 (1.61)**	1.00 (2.14)	3.07 (1.82) *	-1.10 (1.44)	2.95 (1.82)	2.62 (0.86)** *	1.65 (1.48)	0.04 (0.17)	26.70 (10.69)**
ID 11i	-110.02 (51.52) **	-0.06 (0.04)	-0.38 (0.39)	-1.47 (0.72) **	-1.20 (1.48)	3.27 (0.72)** *	1.16 (0.95)	1.56 (1.31)	-0.45 (0.85)	2.60 (1.32)*	-1.51 (0.86) *	2.20 (1.74)	0.10 (1.10)	3.75 (1.75) **	2.85 (0.87)** *	1.40 (1.51)	-0.05 (0.18)	23.46 (10.68)**
ID 11h	-109.78 (51.56) **	-0.06 (0.04)	-0.39 (0.39)	-1.44 (0.71) *&	-1.22 (1.48)	3.27 (0.72)** *	1.15 (0.95)	1.54 (1.31)	-0.45 (0.86)	2.56 (1.31)*	-1.49 (0.86) *	2.21 (1.74)	0.10 (1.10)	3.78 (1.75) **	2.85 (0.87)** *	1.41 (1.51)	-0.04 (0.17)	23.4 (10.69)**

Dropp- ed id	CON S	YEA R	PUB	RC	BT	FRESH	SWAMP	HEM	LAC	COAST	NE	APPA L	MTN	DSP	NPLS	SE	Log.A REA	Log.INC
ID 11g	-109.64 (51.57) **	-0.06 (0.04)	-0.39 (0.39)	-1.43 (0.70) *	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.45 (0.86)	2.53 (1.30)*	-1.48 (0.86) *	2.21 (1.74)	0.10 (1.10)	3.80 (1.74) **	2.85 (0.87)**	1.41 (1.51)	-0.04 (0.17)	23.37 (10.69)**
ID 11f	-109.57 (51.58) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) **	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.45 (0.86)	2.52 (1.30)*	-1.47 (0.86) *	2.21 (1.74)	0.11 (1.10)	3.81 (1.73) **	2.85 (0.87)**	1.41 (1.51)	-0.03 (0.17)	23.35 (10.69)**
ID 11e	-109.51 (51.59) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) **	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.45 (0.86)	2.52 (1.30)*	-1.47 (0.86) *	2.21 (1.74)	0.11 (1.10)	3.82 (1.74) **	2.85 (0.87)**	1.41 (1.52)	-0.03 (0.17)	23.34 (10.70)**
ID 11d	-109.55 (51.59) **	-0.06 (0.04)	-0.38 (0.39)	-1.43 (0.72) *	-1.22 (1.49)	3.27 (0.72)**	1.16 (0.95)	1.55 (1.33)	-0.45 (0.86)	2.53 (1.31)*	-1.48 (0.86) *	2.21 (1.75)	0.11 (1.10)	3.81 (1.74) **	2.85 (0.87)**	1.41 (1.52)	-0.04 (0.18)	23.35 (10.70)**
ID 11c	-109.44 (51.58) **	-0.06 (0.04)	-0.39 (0.39)	-1.41 (0.70) *	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.54 (1.31)	-0.45 (0.86)	2.51 (1.30)*	-1.47 (0.86) *	2.21 (1.74)	0.11 (1.10)	3.82 (1.74) **	2.85 (0.87)**	1.41 (1.51)	-0.03 (0.04)	23.32 (10.70)**
ID 11b	-109.63 (51.52) **	-0.06 (0.04)	-0.37 (0.39)	-1.45 (0.71) *	-1.20 (1.49)	3.28 (0.72)**	1.17 (0.95)	1.58 (1.32)	-0.44 (0.86)	2.56 (1.31)*	-1.49 (0.86) *	2.19 (1.74)	0.12 (1.10)	3.78 (1.74) **	2.85 (0.87)**	1.40 (1.51)	-0.05 (0.18)	23.38 (10.68)**
ID 11a	-109.51 (51.59) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.32)	-0.45 (0.86)	2.52 (1.30)*	-1.47 (0.86) *	2.21 (1.75)	0.11 (1.10)	3.82 (1.74) **	2.85 (0.87)**	1.41 (1.52)	-0.03 (0.17)	23.34 (10.70)**
ID 10	-109.51 (50.50) **	-0.06 (0.04)	-0.39 (0.38)	-1.42 (0.68) **	-1.23 (1.45)	3.27 (0.70)**	1.15 (0.93)	1.53 (1.28)	-	2.52 (1.27)*	-1.47 (0.84) *	2.21 (1.71)	0.11 (1.08)	3.82 (1.70) **	2.85 (0.85)**	1.41 (1.48)	-0.03 (0.17)	23.34 ((10.47)**
ID 9b	-93.52 (62.50)	-0.07 (0.19)	-0.34 (0.40)	-1.75 (1.01) *	-0.66 (1.96)	2.92 (1.06)**	1.02 (0.99)	1.46 (1.31)	-0.61 (0.93)	2.40 (1.32)*	-1.29 (0.94)	1.66 (2.13)	-0.09 (1.18)	3.07 (2.40)	2.57 (1.07)**	0.94 (1.84)	-0.07 (0.19)	20.12 (12.84)
ID 9a	-66.35 (51.87)	-0.03 (0.04)	-0.09 (0.39)	-0.21 (0.87)	-1.08 (1.37)	2.34 (0.80)**	0.62 (0.91)	0.62 (1.28)	-0.13 (0.80)	1.25 (1.34)	-1.06 (0.81)	1.11 (1.69)	-0.49 (1.05)	2.99 (1.64) *	1.63 (0.99)	0.67 (1.44)	0.23 (0.20)	14.07 (10.82)
ID 8	-133.89 (29.08) ***	-0.06 (0.02) ***	-0.09 (0.22)	-1.64 (0.39) **	-1.75 (0.83) **	3.99 (0.41)**	1.600 (0.53)***	2.50 (0.74)*	-0.41 (0.48)	3.04 (0.73)**	-1.81 (0.48) ***	2.78 (0.98) ***	0.74 (0.62)	4.56 (0.98) ***	3.88 (0.51)**	2.16 (0.85) **	-0.08 (0.09)	28.33 (6.03)***
ID 7c	-109.56 (51.38) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) **	-1.23 (1.48)	3.27 (0.71)**	1.04 (0.98)	1.54 (1.30)	-0.45 (0.85)	2.53 (1.29)*	-1.47 (0.85) *	2.21 (1.74)	0.11 (1.09)	3.81 (1.73) **	2.85 (0.87)**	1.41 (1.51)	-0.04 (0.17)	23.35 (10.65)**
ID 7b	-109.24 (51.33) **	-0.06 (0.04)	-0.40 (0.39)	-1.38 (0.70) *	-1.26 (1.48)	3.27 (0.71)**	1.27 (0.98)	1.50 (1.30)	-0.45 (0.85)	2.47 (1.30)*	-1.45 (0.85) *	2.22 (1.74)	0.11 (1.10)	3.86 (1.73) **	2.85 (0.87)**	1.42 (1.51)	-0.02 (0.17)	23.27 (10.64)**
ID 7a	-109.48 (51.59) **	-0.06 (0.04)	-0.39 (0.39)	-1.41 (0.41) *	-1.24 (1.48)	3.27 (0.72)**	1.14 (0.99)	1.53 (1.31)	-0.45 (0.86)	2.51 (1.31)*	-1.47 (0.86) *	2.21 (1.74)	0.11 (1.10)	3.82 (1.74) **	2.85 (0.87)**	1.41 (1.52)	-0.03 (0.17)	23.33 (10.70)**
ID 6	-58.46 (65.60)	-0.08 (0.04) *	-0.51 (0.39)	-1.69 (0.73) **	-0.45 (1.61)	2.83 (0.80)**	1.35 (0.94)	1.59 (1.28)	-0.65 (0.86)	1.57 (1.53)	-0.91 (0.98)	0.85 (2.11)	-0.40 (1.17)	2.99 (1.85)	2.43 (0.93)**	0.12 (1.89)	-0.04 (0.16)	12.79 (14.20)
ID 5d	-109.08 (51.41) **	-0.06 (0.04)	-0.41 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.71)**	1.15 (0.94)	1.52 (1.30)	-0.46 (0.85)	2.48 (1.30)*	-1.45 (0.86) *	2.21 (1.74)	0.10 (1.10)	3.84 (1.73) **	2.85 (0.87)**	1.46 (1.51)	-0.03 (0.17)	23.25 (10.66)**
ID 5c	-109.08 (51.41) **	-0.06 (0.04)	-0.41 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.71)**	1.15 (0.94)	1.52 (1.30)	-0.46 (0.85)	2.48 (1.30)*	-1.45 (0.86) *	2.21 (1.74)	0.10 (1.10)	3.84 (1.73) **	2.85 (0.87)**	1.46 (1.51)	-0.03 (0.17)	23.25 (10.66)**
ID 5b	-109.08 (51.41) **	-0.06 (0.04)	-0.41 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.71)**	1.15 (0.94)	1.52 (1.30)	-0.46 (0.85)	2.48 (1.30)*	-1.45 (0.86) *	2.21 (1.74)	0.10 (1.10)	3.84 (1.73) **	2.85 (0.87)**	1.46 (1.51)	-0.03 (0.17)	23.25 (10.66)**
ID 5a	-109.08 (51.41) **	-0.06 (0.04)	-0.41 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.71)**	1.15 (0.94)	1.52 (1.30)	-0.46 (0.85)	2.48 (1.30)*	-1.45 (0.86) *	2.21 (1.74)	0.10 (1.09)	3.84 (1.73) **	2.85 (0.87)**	1.46 (1.51)	-0.03 (0.17)	23.25 (10.66)**
ID 4	-26.02 (63.77)	0.02 (0.05)	-0.57 (0.37)	-0.51 (0.79)	-1.84 (1.41)	3.68 (0.69)**	2.73 (1.19)**	1.42 (1.21)	0.88 (1.04)	3.40 (1.28)**	-0.81 (0.86)	-0.43 (2.10)	-2.85 (1.81)	1.37 (2.03)	0.60 (1.39)	-1.52 (2.04)	-0.22 (0.18)	5.67 (13.34)
ID 3	-109.51 (50.50) **	-0.06 (0.04)	-0.39 (0.38)	-1.42 (0.68) **	-1.23 (1.45)	3.27 (0.70)**	1.15 (0.93)	omitte d	-0.44 (0.84)	2.52 (1.27)*	-1.47 (0.84) *	2.21 (1.71)	0.11 (1.08)	3.82 (1.70) **	2.85 (0.85)**	1.41 (1.48)	-0.03 (0.17)	23.34 (10.47)**

Dropp- ed id	CON S	YEA R	PUB	RC	BT	FRESH	SWAMP	HEM	LAC	COAST	NE	APPA L	MTN	DSP	NPLS	SE	Log.A REA	Log.INC
ID1b	-109.51 (51.59) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.44 (0.86)	2.52 (1.30)*	-1.47 (0.86) *	2.21 (1.74)	0.10 (1.20)	3.82 (1.73) **	2.85 (0.87)**	1.41 (1.52) ***	-0.03 (0.17)	23.34 (10.70)**
ID 1a	-109.51 (51.59) **	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70) *	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.44 (0.86)	2.52 (1.30)*	-1.47 (0.86) *	2.21 (1.74)	0.12 (1.20)	3.82 (1.73) **	2.85 (0.87)**	1.41 (1.52)	-0.03 (0.17)	23.34 (10.70)**

Appendix 6. OLS Regression Coefficients Dropping One Observation (Model 8)

Dropp- ed id	CON S	YEA R	PU B	RC	BT	FRE SH	SWA MP	HEM	LAC	COA ST	NE	APP AL	MT N	DSP	NPLS	SE	Log.A REA	Log.INC
ID 21	-132.41 (58.23)* *	-0.03 (0.06)	-1.44 (0.65) **	-0.51 (0.86)	-2.87 (1.74)	3.73 (0.87)** *	1.11 (1.15)	-0.96 (2.00)	-0.83 (1.07)	1.50 (1.61)	-1.17 (1.03)	3.74 (2.00) *	-0.56 (1.16)	6.49 (2.03) ***	3.49 (0.98)** *	1.66 (1.75)	0.38 (0.30)	27.68 (12.08)**
ID 20	-145.21 (64.20)* *	-0.03 (0.06)	-0.54 (0.55)	-0.68 (0.95)	omitt ed	3.98 (0.95)** *	1.36 (1.27)	0.24 (2.13)	-0.16 (1.13)	2.79 (1.65)	-1.85 (1.09)	3.49 (2.21)	-0.16 (1.27)	5.45 (2.18) **	3.45 (1.09)** *	2.47 (1.89)	0.08 (0.30)	30.50 (13.31)**
ID 19	-145.21 (64.20)* *	-0.03 (0.06)	-0.54 (0.55)	-0.68 (0.95)	omitt ed	3.98 (0.95)** *	1.36 (1.27)	0.24 (2.13)	-0.16 (1.13)	5.35 (2.47)**	-1.85 (1.09)	3.49 (2.21)	-0.16 (1.27)	2.88 (1.46) *	3.45 (1.09)** *	2.47 (1.89)	0.08 (0.30)	30.50 (13.31)**
ID 18b	-148.77 (72.88)* *	-0.03 (0.07)	-0.54 (0.57)	-0.69 (0.98)	-2.57 (1.98)	4.00 (1.01)** *	1.34 (1.32)	0.23 (2.20)	-0.14 (1.18)	2.85 (1.80)	-1.90 (1.18)	3.56 (2.43)	0.11 (1.38)	5.50 (2.30) **	3.47 (1.45)** *	2.56 (2.09)	0.07 (0.32)	31.25 (15.16)*
ID 18a	-201.98 (63.92)* **	-0.05 (0.06)	-0.57 (0.50)	-0.85 (0.86)	-2.62 (1.73)	4.41 (0.89)** *	1.16 (1.15)	0.13 (1.93)	0.16 (1.03)	3.88 (1.58)**	-2.57 (1.04) **	5.06 (2.13) **	0.64 (1.21)	6.31 (2.02) ***	3.89 (1.00)** *	3.88 (1.84) *	-0.07 (0.28)	42.53 (13.30)***
ID 17	-145.21 (64.20)* *	-0.03 (0.06)	-0.54 (0.55)	-0.68 (0.95)	omitt ed	3.98 (0.95)** *	1.36 (1.27)	0.24 (2.13)	-0.16 (1.13)	2.79 (1.65)	-1.85 (1.09)	3.49 (2.21)	-0.16 (1.27)	2.88 (1.46) *	3.45 (1.09)** *	2.47 (1.89)	0.08 (0.30)	30.50 (13.31)**
ID 16	-145.21 (64.20)* *	-0.03 (0.06)	-0.54 (0.55)	-0.68 (0.95)	-2.56 (1.92)	3.98 (0.95)** *	omitted	-1.12 (1.51)	-0.16 (1.13)	2.79 (1.65)	-1.85 (1.09)	4.85 (1.99) **	-0.16 (1.27)	5.45 (2.18) **	3.45 (1.09)** *	2.47 (1.89)	0.08 (0.30)	30.50 (13.31)**
ID 15c	-146.11 (66.83)* *	-0.03 (0.07)	-0.56 (0.58)	-0.67 (0.98)	-2.58 (1.99)	3.98 (0.99)** *	1.35 (1.32)	0.20 (2.23)	-0.17 (1.17)	2.79 (1.71)	-1.83 (1.14)	3.54 (2.34)	-0.14 (1.31)	5.49 (2.30) **	3.47 (1.15)** *	2.51 (1.99)	0.09 (0.31)	30.68 (13.84)**
ID 15b	-145.09 (66.86)* *	-0.03 (0.07)	-0.54 (0.59)	-0.68 (0.98)	-2.56 (1.99)	3.98 (0.99)** *	1.36 (1.32)	0.25 (2.23)	-0.16 (1.17)	2.78 (1.71)	-1.86 (1.14)	3.48 (2.34)	-0.16 (1.31)	5.44 (2.30) **	3.44 (1.15)** *	2.46 (1.99)	0.08 (0.31)	30.47 (13.85)**
ID 15a	-137.51 (65.03)* *	-0.04 (0.06)	-0.41 (0.57)	-0.71 (0.95)	-2.36 (1.94)	3.95 (0.96)** *	1.44 (1.28)	0.57 (2.17)	-0.07 (1.14)	2.73 (1.66)	-2.05 (1.11) *	3.02 (2.28)	-0.27 (1.28)	5.02 (2.24) **	3.21 (1.12)** *	2.12 (1.94)	0.04 (0.30)	28.96 (13.47)**
ID 14b	-146.16 (67.14)* *	-0.03 (0.07)	-0.52 (0.62)	-0.67 (0.99)	-2.57 (1.98)	3.98 (0.99)** *	1.36 (1.31)	0.26 (2.21)	-0.14 (1.18)	2.81 (1.73)	-1.86 (1.12)	3.52 (2.32)	-0.12 (1.37)	5.46 (2.26) **	3.47 (1.15)** *	2.52 (2.03)	0.08 (0.31)	30.69 (13.91)**
ID 14a	-151.89 (66.34)* *	-0.03 (0.06)	-0.38 (0.62)	-0.63 (0.97)	-2.59 (1.96)	4.05 (0.98)** *	1.37 (1.30)	0.40 (2.19)	-0.03 (1.17)	2.99 (1.72)*	-1.91 (1.11)	3.71 (2.28)	0.10 (1.36)	5.54 (2.23) **	3.62 (1.14)** *	2.79 (1.99)	0.05 (0.31)	31.86 (13.75)**
ID 13d	-144.75 (66.53)* *	-0.03 (0.07)	-0.54 (0.57)	-0.68 (0.98)	-2.56 (1.98)	3.96 (1.00)** *	1.35 (1.32)	0.24 (2.20)	-0.17 (1.17)	2.78 (1.71)	-1.85 (1.12)	3.47 (2.29)	-0.17 (1.32)	5.43 (2.27) **	3.43 (1.13)** *	2.45 (1.97)	0.08 (0.31)	30.41 (13.78)**
ID 13c	-141.59 (65.65)* *	-0.03 (0.06)	-0.55 (0.56)	-0.63 (0.97)	-2.59 (1.95)	3.83 (0.99)** *	1.26 (1.30)	0.10 (2.18)	-0.26 (1.16)	2.65 (1.70)	-1.82 (1.11)	3.38 (2.26)	-0.26 (1.30)	5.35 (2.23) **	3.35 (1.12)** *	2.35 (1.94)	0.07 (0.30)	29.76 (13.61)**
ID 13b	-145.98 (66.53)* *	-0.03 (0.07)	-0.53 (0.75)	-0.70 (0.99)	-2.54 (1.98)	4.01 (1.02)** *	1.39 (1.33)	0.29 (2.24)	-0.14 (1.18)	2.83 (1.73)	-1.87 (1.13)	3.50 (2.29)	-0.13 (1.33)	5.45 (2.26) **	3.47 (1.13)** *	2.49 (1.96)	0.08 (0.31)	30.66 (13.79)**
ID 13a	-144.21 (66.47)* *	-0.03 (0.07)	-0.53 (0.57)	-0.68 (0.98)	-2.55 (1.98)	3.94 (1.00)** *	1.35 (1.31)	0.24 (2.20)	-0.18 (1.17)	2.77 (1.71)	-1.86 (1.12)	3.44 (2.30)	-0.18 (1.31)	5.40 (2.27) **	3.42 (1.13)** *	2.43 (1.97)	0.07 (0.31)	30.31 (13.77)**
ID 12	-149.60 (68.55)* *	-0.01 (0.12)	-0.65 (0.71)	-0.80 (1.10)	-2.70 (2.06)	3.78 (1.28)** *	1.09 (1.69)	-0.47 (3.65)	-0.43 (1.61)	3.10 (2.14)	-1.20 (2.89)	3.71 (2.46)	-0.49 (1.88)	5.23 (2.42) **	3.39 (1.15)** *	2.53 (1.97)	0.10 (0.32)	31.36 (14.16)**
ID 11i	-110.02 (51.52)* *	-0.06 (0.04)	-0.38 (0.04)	-1.47 (0.72) *	-1.20 (1.48)	3.27 (0.72)** *	1.16 (0.95)	1.56 (1.31)	-0.45 (0.85)	2.60 (1.32)*	-1.51 (0.86) *	2.20 (1.74)	0.10 (1.10)	3.75 (1.75) **	2.85 (0.87)** *	1.40 (1.51)	-0.05 (0.18)	23.46 (10.68)**
ID 11h	-109.78 (51.56)* *	-0.06 (0.04)	-0.38 (0.39)	-1.44 (0.71) *	-1.22 (1.48)	3.27 (0.72)** *	1.15 (0.95)	1.54 (1.31)	-0.45 (0.86)	2.56 (1.31)*	-1.49 (0.86) *	2.21 (1.74)	0.10 (1.10)	3.78 (1.74) **	2.85 (0.87)** *	1.41 (1.51)	-0.04 (0.17)	23.40 (10.69)**

Dropp- ed id	CON S	YEA R	PU B	RC	BT	FRE SH	SWA MP	HEM	LAC	COA ST	NE	APP AL	MT N	DSP	NPLS	SE	Log.A REA	Log.INC
ID 11g	-109.64 (51.57)*	-0.06 (0.04)	-0.39 (0.39)	-1.43 (0.70)*	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.45 (0.86)	2.53 (1.30)*	-1.48 (0.86)*	2.21 (1.74)	0.10 (1.10)	3.80 (1.74)**	2.85 (0.87)**	1.41 (1.51)	-0.04 (0.17)	23.37 (10.69)**
ID 11f	-109.57 (51.58)*	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70)*	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.45 (0.86)	2.52 (1.30)*	-1.47 (0.86)*	2.12 (1.74)	0.11 (1.10)	3.81 (1.73)**	2.85 (0.87)**	1.41 (1.51)	-0.03 (0.17)	23.35 (10.70)**
ID 11e	-109.51 (51.59)*	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70)*	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.31)	-0.45 (0.86)	2.52 (1.30)*	-1.47 (0.86)*	2.21 (1.74)	0.11 (1.10)	3.82 (1.73)**	2.85 (0.87)**	1.41 (1.52)	-0.03 (0.17)	23.34 (10.70)**
ID 11d	-109.55 (51.59)*	-0.06 (0.04)	-0.39 (0.39)	-1.43 (0.72)*	-1.22 (1.49)	3.27 (0.72)**	1.16 (0.95)	1.55 (1.33)	-0.44 (0.86)	2.53 (1.31)*	-1.48 (0.86)*	2.21 (1.75)	0.11 (1.10)	3.81 (1.74)**	2.85 (0.87)**	1.41 (1.52)	-0.04 (0.18)	23.35 (10.70)**
ID 11c	-109.44 (51.58)*	-0.06 (0.04)	-0.39 (0.39)	-1.41 (0.70)	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.54 (1.31)	-0.44 (0.86)	2.51 (1.30)*	-1.47 (0.86)*	2.21 (1.74)	0.11 (1.10)	3.82 (1.74)**	2.85 (0.87)**	1.41 (1.51)	-0.03 (0.17)	23.32 (10.70)**
ID 11b	-109.63 (51.52)*	-0.06 (0.04)	-0.37 (0.39)	-1.45 (0.71)*	-1.20 (1.49)	3.28 (0.72)**	1.17 (0.95)	1.59 (1.32)	-0.44 (0.86)	2.55 (1.31)*	-1.49 (0.86)*	2.19 (1.74)	0.12 (1.10)	3.78 (1.74)**	2.85 (0.87)**	1.40 (1.51)	-0.05 (0.18)	23.38 (10.68)**
ID 11a	-109.51 (51.58)*	-0.06 (0.04)	-0.39 (0.39)	-1.42 (0.70)*	-1.23 (1.48)	3.27 (0.72)**	1.15 (0.95)	1.53 (1.32)	-0.45 (0.86)	2.52 (1.30)*	-1.47 (0.86)*	2.21 (1.75)	0.11 (1.10)	3.82 (1.74)**	2.85 (0.87)**	1.41 (1.52)	-0.03 (0.17)	23.34 (10.70)**
ID 10	-145.21 (64.20)*	-0.03 (0.06)	-0.54 (0.55)	-0.68 (0.95)	-2.56 (1.92)	3.98 (0.95)**	1.36 (1.27)	0.24 (2.13)	omitted	2.79 (1.65)	-1.85 (1.09)	3.49 (2.21)	-0.16 (1.27)	5.45 (2.18)**	3.45 (1.09)**	2.47 (1.89)	0.08 (0.30)	30.50 (13.31)**
ID 9b	-89.58 (77.98)	-0.07 (0.07)	-0.30 (0.58)	-1.96 (1.41)	-0.42 (2.58)	2.83 (1.33)**	1.00 (1.29)	0.75 (2.14)	-0.66 (1.19)	2.51 (1.64)	-1.31 (1.16)	1.47 (2.74)	-0.54 (1.29)	2.72 (3.10)	2.48 (1.33)*	0.78 (2.32)	-0.13 (0.34)	19.37 (15.97)
ID 9a	outlier																	
ID 8	-171.12 (34.33)**	-0.05 (0.03)	-0.17 (0.30)	-0.99 (0.51)*	-3.01 (1.02)**	4.81 (0.52)**	1.93 (0.68)**	1.32 (1.14)	0.05 (0.60)	3.41 (0.88)**	-2.25 (0.58)**	4.01 (1.18)**	0.49 (0.68)	6.17 (1.67)**	4.57 (0.60)**	3.24 (1.01)**	-0.01 (0.16)	35.85 (7.12)**
ID 7c	-145.24 (66.09)*	-0.03 (0.07)	-0.54 (0.57)	-0.69 (0.98)	-2.55 (1.97)	3.98 (0.98)**	1.26 (1.35)	0.26 (2.20)	-0.16 (1.16)	2.80 (1.70)	-1.86 (1.12)	3.48 (2.28)	-0.15 (1.30)	5.43 (2.25)**	3.45 (1.12)**	2.46 (1.95)	0.08 (0.31)	30.51 (13.70)**
ID 7b	-145.03 (66.08)*	-0.03 (0.07)	-0.58 (0.57)	-0.59 (0.99)	-2.64 (1.97)	3.94 (0.98)**	1.48 (1.33)	0.09 (2.21)	0.20 (1.16)	2.70 (1.70)	-1.81 (1.12)	3.54 (2.27)	-0.19 (1.30)	5.53 (2.25)**	3.44 (1.14)**	2.50 (1.94)	0.12 (0.32)	30.42 (13.64)**
ID 7a	-145.14 (66.25)*	-0.03 (0.07)	-0.56 (0.57)	-0.64 (1.00)	-2.59 (1.99)	3.96 (0.99)**	1.28 (1.41)	0.18 (2.24)	-0.18 (1.17)	2.75 (1.72)	-1.83 (1.13)	3.51 (2.29)	-0.17 (1.31)	5.48 (2.26)**	3.44 (1.12)	2.48 (1.95)	0.09 (0.32)	30.46 (13.73)**
ID 6	-129.80 (93.21)	-0.04 (0.08)	-0.56 (0.57)	-0.78 (1.08)	-2.29 (2.29)	3.87 (1.08)**	1.46 (1.38)	0.49 (2.44)	-0.19 (1.17)	2.52 (2.05)	-1.70 (1.30)	3.05 (2.95)	0.21 (1.33)	5.18 (2.52)	3.33 (1.22)	2.07 (2.58)	0.06 (0.32)	27.33 (19.23)
ID 5d	-144.77 (66.04)*	-0.03 (0.07)	-0.57 (0.57)	-0.67 (0.98)	-2.57 (1.97)	3.97 (0.98)**	1.35 (1.31)	0.20 (2.20)	-0.18 (1.16)	2.74 (1.71)	-1.83 (1.12)	3.50 (2.28)	-0.17 (1.30)	5.48 (2.25)**	3.45 (1.12)**	2.53 (1.95)	0.09 (0.31)	30.40 (13.69)**
ID 5c	-144.77 (66.04)*	-0.03 (0.07)	-0.57 (0.57)	-0.67 (0.98)	-2.57 (1.97)	3.97 (0.98)**	1.35 (1.31)	0.20 (2.20)	-0.18 (1.16)	2.74 (1.71)	-1.83 (1.12)	3.50 (2.28)	-0.17 (1.30)	5.48 (2.25)**	3.45 (1.12)**	2.53 (1.95)	0.09 (0.31)	30.40 (13.69)**
ID 5b	-144.77 (66.04)*	-0.03 (0.07)	-0.57 (0.57)	-0.67 (0.98)	-2.57 (1.97)	3.97 (0.98)**	1.35 (1.31)	0.20 (2.20)	-0.18 (1.16)	2.74 (1.71)	-1.83 (1.12)	3.50 (2.28)	-0.17 (1.30)	5.48 (2.25)**	3.45 (1.12)**	2.53 (1.95)	0.09 (0.31)	30.40 (13.69)**
ID 5a	-144.77 (66.04)*	-0.03 (0.07)	-0.57 (0.57)	-0.67 (0.98)	-2.57 (1.97)	3.97 (0.98)**	1.35 (1.31)	0.20 (2.20)	-0.18 (1.16)	2.74 (1.71)	-1.83 (1.12)	3.50 (2.28)	-0.17 (1.30)	5.48 (2.25)**	3.45 (1.12)**	2.53 (1.95)	0.09 (0.31)	30.40 (13.69)**
ID 4	1.07 (74.63)	0.06 (0.06)	-0.63 (0.46)	0.51 (0.90)	-3.13 (1.61)*	4.97 (0.87)**	4.51 (1.54)**	2.38 (1.94)	2.43 (1.32)*	4.65 (1.53)**	-0.90 (0.97)	-1.48 (2.55)	-4.38 (1.83)**	0.84 (2.45)	-0.40 (1.64)	-2.80 (2.45)	-0.45 (0.31)	-0.23 (15.57)
ID 3	-145.21 (64.20)*	-0.03 (0.07)	-0.54 (0.55)	-0.67 (0.95)	-2.56 (1.92)	3.98 (0.95)**	1.36 (1.27)	omitted	-0.16 (1.13)	2.79 (1.65)	-1.85 (1.09)	3.49 (2.21)	-0.16 (1.27)	5.45 (2.18)**	3.45 (1.09)**	2.47 (1.89)	0.08 (0.30)	30.50 (13.31)**

Dropp- ed id	CON S	YEA R	PU B	RC	BT	FRE SH	SWA MP	HEM	LAC	COA ST	NE	APP AL	MT N	DSP	NPLS	SE	Log.A REA	Log.INC
ID 2	Outlier excluded (this wetland is in Ontario, CA)																	
ID1b	-145.21 (66.30)*	-0.03 (0.07)	-0.54 (0.57)	-0.67 (0.98)	-2.56 (1.98)	3.97 (0.99)**	1.36 (1.31)	0.24 (2.21)	-0.16 (1.17)	2.78 (1.71)	-1.85 (1.12)	3.49 (2.28)	0.14 (1.43)	5.45 (2.26)**	3.45 (1.12)**	2.47 (1.95)	0.08 (0.31)	30.49 (13.74)**
ID 1a	-145.21 (66.30)*	-0.03 (0.07)	-0.54 (0.57)	-0.67 (0.98)	-2.56 (1.98)	3.97 (0.99)**	1.36 (1.31)	0.24 (2.21)	-0.16 (1.17)	2.78 (1.71)	-1.85 (1.12)	3.49 (2.28)	-0.17 (1.46)	5.45 (2.26)**	3.45 (1.12)**	2.47 (1.95)	0.08 (0.31)	30.50 (13.74)**

Appendix 6. USDA Economic Research Service (ERS) Regions, USA

<i>Northeast</i>	<i>Delta States</i>
Maine	Arkansas
New Hampshire	<i>Louisiana</i>
Vermont	Mississippi
<i>Massachusetts</i>	
Rhode Island	<i>Southern Plains</i>
Connecticut	Oklahoma
New York	<i>Texas</i>
<i>New Jersey</i>	
Pennsylvania	<i>Mountain</i>
Delaware	Montana
Maryland	Idaho
District of Columbia	Wyoming
	Colorado
<i>Lake States</i>	New Mexico
<i>Michigan</i>	Arizona
<i>Wisconsin</i>	Utah
<i>Minnesota</i>	<i>Nevada</i>
<i>Northern Plains</i>	<i>Pacific</i>
North Dakota	Washington
<i>South Dakota</i>	Oregon
Nebraska	<i>California</i>
Kansas	
	<i>Southeast</i>
<i>Appalachian</i>	<i>Georgia</i>
Virginia	<i>Florida</i>
<i>West Virginia</i>	<i>Alabama</i>
North Carolina	
<i>Kentucky</i>	
Tennessee	

Source: www.ers.usda.gov/datafiles/Major_Land_Uses/Summary

Appendix 7. Massachusetts Wetland Features from Gupta and Foster paper (1975)

Sources used

GNIS: USGS Geographic Names Information System – these are the named features on topographic maps. <http://geonames.usgs.gov/>

NWI: National Wetlands Inventory (US Fish and Wildlife Service). Wetland polygon boundaries, downloaded by state: <http://www.fws.gov/wetlands/data/Data-Download.html>.

CBI-PAD: Conservation Biology Institute Protected Areas Database v2. Boundaries and names for state, local, and federal parks and other conservation features: <http://consbio.org/products/projects/pad-us-cbi-edition>.

Area of features

All areas are approximate (shape file with features related to each located wetland is available).

Feature Name	Located	Area (acres)
White Cedar Bog	Yes	18.5
Otis Fresh Marsh	No	7.41
Bear Meadow	Yes	245.1
Hyannis Wooded Swamp	No	4.94
Moores Pond	Yes	55.1
Chicopee River Marshes	Yes	125.3
Hoosic River Swamp	Yes	270.4
Lawrence Swamp	Yes	938.7
Wenham Swamp	Yes	2,240.2

White Cedar Bog

Springfield, Hampden County, MA

Municipal Park feature located using Conservation Biology Institute Protected Areas Database v2. <http://consbio.org/products/projects/pad-us-cbi-edition> .

Corresponding wetland feature located in NWI from USFWS: Area of wetland feature: 18.52 acres.

Otis Fresh Marsh

Berkshire County MA

Feature not found as Otis in NWI, CBI-PAD, and GNIS (USGS). Nearby pond's approximate area 7.41 acres.

Bear Meadow (Whitman)

Found Bear Meadow in CBI-PAD database, selected all NWI wetland polygons intersecting this area. Also in GNIS. Area is 245.13 acres total (all wetland polygons in area).

Hyannis Wooded Swamp (Hyannis)

Could not locate feature. There is a WMA named "Hyannis Ponds WMA" but this includes ponds, not wooded swamps. Approximate area 4.94 acres.

Moore's Pond (Warwick)

Found Moores Pond feature in GNIS, found corresponding polygons in NWI. All NWI polygons in area total 55.1 acres.

Chicopee River Marshes (Chicopee)

Selected related NWI polygons along Chicopee River. Total area 125.3 acres.

Hoosic River Swamp (Cheshire)

Selected related NWI polygons along Hoosic River. Total area 270.4 acres.

Lawrence Swamp (Amherst)

Selected related NWI polygons within Lawrence Swamp. Named feature in CBI-PAD, and also on topo maps. Total area 938.7 acres.

Wenham Swamp (Wenham)

Selected related NWI polygons within Wenham Swamp. Named feature in CBI-PAD, and also on topo maps. Total area 2,240.2 acres.

(Downloaded from websites and shape file created on Dec. 4, 2014).

Note: This dissertation research was not sponsored by any agencies or persons financially and materially.

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