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Valuing the Ecosystem Services of Florida's Forest Conservation Programs: The Economic Benefits of Protecting Water Quality[1]

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Introduction

Forested ecosystems in Florida provide many kinds of ecosystem services, such as recreation, wildlife habitat, and carbon sequestration. One of the most beneficial services forests provide is the improvement of water quality through the reduction of pollutants, such as increased nutrients that result from various human activities. This paper will discuss the results of a study that examined the value of protecting water quality in Florida, and it will provide estimates of what Floridians may be willing to pay (WTP) for water quality protection programs that include forest conservation. Information about the value of using forest conservation to protect water quality in fresh water systems in Florida is limited, which makes it difficult to adequately account for the benefits associated with clean water when promoting the value of Florida's forests or when conducting economic analyses used in local and regional planning and policy formulation. One way to estimate the economic value of forest ecosystem services associated with clean water is to use an economic valuation method called "benefit transfer," or sometimes "meta-analysis." Benefit transfer uses an econometric model that takes economic dollar values from similar studies and applies those values to a specific or "new" site, adjusting for the characteristics of the new site. For an example of a benefit transfer see Figure 2.

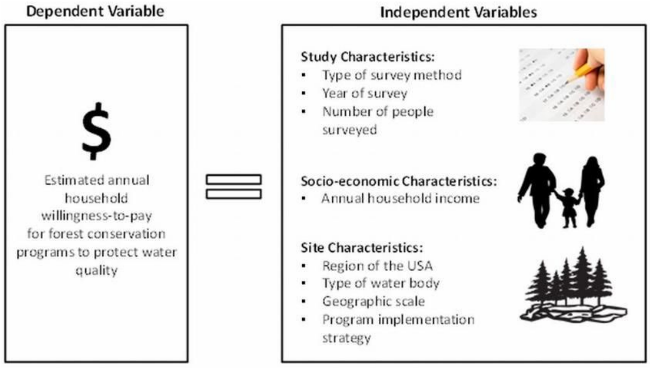

Figure 1. Conceptual model of a meta-analysis model used to determine the statistical relationship among independent variables and the dependent variable (willingness-to-pay).

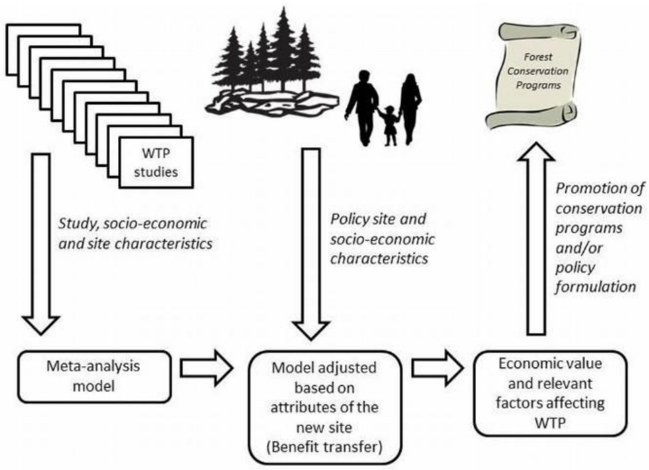

Figure 2. Conceptual model of how economic value estimates of program benefits can be transferred to a new site, or the policy site, using a meta-analysis of willingness-to-pay (WTP) valuation studies.

This publication will present the results of a benefit transfer approach used to estimate the value of the water quality protection services provided by forests in Florida. Specifically it will introduce and discuss:

1. How forest ecosystems reduce non-point source pollution in surface waters and how this ecosystem service benefits humans;
2. How economic analyses can be used to assign a monetary value, or public willingness-to-pay, for this service;
3. The results of a meta-analysis/benefit transfer approach to estimate the economic value of water quality protection and forest conservation programs in different regions of Florida; and, finally,
4. A discussion about the drivers of WTP for different types of water protection programs, and a review of the implications and potential applications of this study.

Land-use decision makers such as county environmental department personnel, county commissioners, planners, and state and federal land and water quality managers can use this publication to educate policy makers and the general public about the value of ecosystem services provided by Florida's forests—specifically those ecosystem services related to water quality protection. This publication also will provide general estimates that can be used in planning/policy related economic analysis.

Protecting Water Quality with Forest Conservation

Non-point Source Water Pollution

Non-point source (NPS) nutrient pollution of surface waters is the introduction of excess nutrients into surface water bodies from land runoff and seepage. This type of pollution causes environmental problems such as algae blooms and depletion of oxygen and is a leading cause of water impairment in the United States and Florida (EPA 1996; Hauxwell et al., 2001). Forest ecosystems have key functions that affect water supply and quality, such as filtering, retention, and storage of water in streams, lakes, and aquifers. The filtering function, or retention of excess nutrients, is mainly performed by the vegetation cover and soil microbes (de Groot et al., 2002). These functions buffer aquatic ecosystems against NPS pollution and provide clean water, a service that greatly benefits humans. Urban and agricultural activities as well as forest management practices can result in NPS pollution associated with road-building, logging, and land-clearing activities. Such activities alter the structure and function of forest ecosystems and hence affect the provision of water quality protection services (Farber et al., 2002; MEA 2005). Human actions that change forest ecosystems often reduce the benefits those ecosystems otherwise would provide. Recreational experiences (fishing, swimming, and aesthetic values); pollution-mitigating services (waste decomposition and nutrient cycling); and supporting services (water purification) all may decrease (Dodds et al., 2008). The decision to conserve forestland is an important step toward reducing stress on aquatic ecosystems so that they continue to provide clean water services and maintain the benefits associated with good water quality (Wainger and Mazzotta 2011). To ensure that forests perform their role in maintaining water quality, policies often use various types of forest conservation programs and approaches.

Forest Conservation Programs

The objective of many forest conservation programs is to use management practices that preserve or conserve ecosystem structure and function in forest lands, in mixed land-use areas, and especially in riparian areas. These programs are often implemented using strategies such as land acquisition and conservation easements (Demers and Carter 2011), as well as landowner incentives or assistance programs (Blaine and Smith 2006). Some examples of forest conservation programs include the Florida Forever Program, a lands acquisition program that protects Florida's surface and groundwater quality (https://floridadep.gov/lands/environmental-services/content/florida-forever), and the Florida Forest Stewardship Program, an education program that assists non-industrial private landowners in managing their lands for long-term environmental, economic, and social benefits (https://ffgs.ifas.ufl.edu/extension/forest-health-and-stewardship/; Ricci et al., 2010).

Valuing Ecosystem Services Provided by Forests

Valuing the Environment

The public's WTP for programs that improve the environment is often measured using a specific survey method known as contingent valuation (CV). This survey method asks respondents how much they would pay for a water quality protection program with specific characteristics providing for certain benefits such as fishing, swimming, and aesthetic values (Mitchell and Carson 1989; Just et al., 2004). Determining the public's WTP for forest conservation programs gives each program a "value," so the public or policy makers can better weigh the advantages and disadvantages of various types of forest conservation programs and the likelihood that they will assist with the achievement of nutrient pollution reduction objectives (Farber et al., 2002; Condon 2004; Lee et al., 2007). Contingent valuation can also help formulate cost-effective conservation and land-use policies that will help develop conservation programs that provide the greatest possible ecosystem services given fixed budgets.

Previous Studies That Value Water Quality Protection Programs

When reviewing which water quality economic valuation studies were relevant for this analysis we found that few focused exclusively on WTP for protecting relatively unpolluted aquatic systems. Moreover, most studies vaguely described the proposed water protection programs as "environmental programs," leaving us with little understanding about other important program characteristics, such as how the program would be implemented (Greenley et al., 1981; Aiken 1985; Whitehead 1990; Sanders et al., 1990; Holmes et al., 2004; and Petrolia 2011). Only a few studies specify the use of land conservation tools such as land acquisition and conservation easements to produce specific water quality benefits (Condon 2004; Cho et al., 2005; Blaine and Smith 2006). It is therefore important to compare WTP for programs that use specified tools like land acquisition and easements with WTP for programs that do not list tools or use relatively vague descriptors like "environmental programs." A respondent's WTP might be influenced by the amount of information provided on the survey.

Data Collection, Analysis, and Benefit Transfer

We compiled the economic valuation data using a comprehensive literature review of 17 studies that examined WTP for the maintenance or protection of benefits associated with unpolluted aquatic resources; this provided us with 43 WTP observations (Table 1). The literature review included refereed and professional publications, technical reports, and other "grey" literature. All studies in the comprehensive review met the following criteria: 1) valued in-stream fresh water resources were considered to be relatively unpolluted; and 2) contingent valuation methods were used to estimate WTP.

Next, we used a meta-analysis model to determine the statistical relationship among WTP and other study characteristics, such as survey method (e.g., survey type, year of survey, number of people that responded to the survey); socioeconomics (e.g., annual household income); and site attributes (e.g., geographic region, type of water body, geographic scale, type of program implementation strategy). A conceptual model of a meta-analysis can be found in Figure 1. A full description of variable characteristics used in this analysis can be found in Table 2, and the results of the meta-analysis can be found in Table 3.

Finally, we conducted a benefit transfer by adjusting the meta-analysis model based on the characteristics of a new site often referred to as a "policy site" (Boyle et al., 2010). Figure 2 shows a conceptual model of how a meta-analysis can be used to conduct a benefit transfer to the policy site. In our case, the policy sites were four regions in Florida (see Table 4 for a list of Florida counties in each region). The characteristics we adjusted for include average annual household income for each region of Florida, region (southeastern USA), resource (all water bodies), scale (drainage basin), and program (land acquisition/conservation easement program and non-specific environmental program).

Economic Value of Water Quality-Related Forest Conservation Programs

Results of the Meta-Analysis Model

The meta-analysis model found all of the study variables to be significant predictors of WTP, which indicates that this model may be useful in describing public preferences for water protection programs.

Overall, respondents were willing to pay:

- Increasingly more over the last 35 years to protect water quality, even after accounting for an increase in annual household income.
- Slightly less to protect water quality in the southeastern United States compared to other regions in the country.
- Slightly more to protect lakes, wetlands, or all water resources in the study area, compared to just rivers and streams.
- More for programs that protect water resources within their own drainage basin or watershed.

Less for programs that propose the use of land acquisition or conservation easements compared to programs that do not state how the program would be implemented.

Results of the Benefit Transfer

For programs that used land acquisition or conservation easements to protect all surface water resources within a drainage basin, we estimated that annual household WTP would range from $3.32 in the panhandle to $4.79 in central Florida (Table 5). Total annual WTP would be around $1,714,000 in the Florida Panhandle, $4,162,000 in north Florida, $7,280,000 in central Florida and $3,933,155 in south Florida for a statewide total combined annual value of almost $17 million. Households' annual WTP for non-specific programs or programs that do not use acquisition or easement approaches to protect all water resources was estimated to range from $64.81 per individual household in the Panhandle to $94.01 per individual household in central Florida. Total annual WTP was around $33,418,000 in the Florida Panhandle, $81,565,000 in north Florida, $142,803,000 in central Florida and $77,100,000 in south Florida for a total combined annual value of almost $335 million for the entire state of Florida (Table 5).

Conclusions and Implications

Our economic analysis showed that WTP has increased over the last 35 years, suggesting that the public is willing to pay more every year to protect relatively unpolluted water resources. This result is not unexpected because urban pressures from population growth in Florida and other regions in the United States increase the need for reliably unpolluted water for human populations even as they leave water supplies increasingly vulnerable to harm. The results of this study indicate that policy makers should consider the importance and benefits that are likely provided by existing programs such as Florida Forever and the Florida Forest Stewardship; programs that conserve forests and protect Florida's unpolluted water resources. Related studies describe similar forest conservation programs have resulted in a significant reduction in water pollution (Frank et al., 2012). The results of the meta-analysis highlight some key biophysical (region, resource) and socioeconomic (income) factors that likely influence WTP and may be helpful when formulating policies or developing water-quality-related forest conservation program characteristics. The benefit transfer of total WTP highlights the substantial economic value individuals may place on forest conservation and water quality protection.

Of interest, the analysis also found that WTP was lower for programs that use land acquisition or conservation easements compared to programs that do not state how they will be implemented. Results suggest that public support and WTP for forest conservation programs are likely not independent of program design, which has implications for WTP estimation and reliance on existing studies to inform policy decisions. Additional research is needed to determine whether this sensitivity in WTP is due to information availability (e.g., in the absence of program details, respondents make assumptions about the program); measurement error (e.g., important attributes are omitted from the study); attitudes and beliefs about how forests should be used and who should manage them (e.g., a belief that certain policy strategies represent an inappropriate use of public authority); or other important factors.

Overall, the results of these study can be used to gain a better understanding of the economic benefits of forest-provided ecosystem services, like the protection and maintenance of water quality, and they may be used to conduct a cost/benefit analysis and/or to estimate the total amount of potential funds that could be made available to support a water quality protection program through taxes or fees. The information presented in this publication can also be used to help decision makers understand the priorities of individuals regarding forest conservation and water resource protection strategies.

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Table 1. Characteristics of valuation studies estimating Willingness to Pay (WTP) for the maintenance or protection of benefits associated with well conserved aquatic resources.

Study	Observation per study[1]	Program process	Water body type[2]	Scale	Valuation methodology	State	Adjusted individual annual WTP values (for a water protection program; in 2010 dollars)[3]
Aiken (1985)	4	Not specified	River and lakes	Statewide	CV-iterative bidding and open ended	Colorado	13.43–31.02
Blaine and Smith (2006)	2	Easement	River/ stream	Region in state	Other	Ohio	7.59–13.18
Blaine et al., (2003)	1	Easement	All water resources	Region in state	CV-Dichotomous choice	Ohio	11.06
Blaine and Lichtkoppler (2004)	1	Easement	Wetland	Region in state	Dichotomous choice	Ohio	17.53
Cho et al., (2005)	2	Easement	All water resources	Region in state	CV-Dichotomous choice	Oregon	4.95–9.85
Condon (1996)	2	Acquisition and Easement	All water resources	Region in state	Attribute based choice experiment	North Carolina	17.07–20.37
Giraud et al., (2001)	3	Not specified	River/ stream	Region in state	CV-Dichotomous choice	Colorado	237.77–269.73
Greenley et al., (1981)	5	Not specified	River/ stream	Region in state	CV-Dichotomous choice	Colorado	8.38–59.34
Hanemann et al., (1991)	2	Not specified	Wetland/ estuary	Region in state	CV-Dichotomous choice	California	82.32–139.32
Holmes et al., (2004)	3	Not specified	River/ stream	Specific site	CV-Dichotomous choice	North Carolina	12.74–25.12
Mannesto and Loomis (1991)	2	Not specified	Wetland/ estuary	Specific site	CV-Payment card	California	29.43–54.24
Petrolia et al., (2011)	2	Not specified	Wetland/ estuary	Region in state	CV-Dichotomous choice	Louisiana	221.11–266.48
Sanders et al., (1990)	4	Not specified	River/ stream	Region in state	CV-open ended	Colorado	14.15–32.08
Shrestha and Alavalapati (2004)	2	Landowner incentives	Lake	Specific site	Other	Florida	14.84–34.92
Sutherland and Walsh (1985)	4	Not specified	River/ stream	Region in state	CV-open ended	Montana	6.05–21.64
Whitehead (1990)	2	Not specified	Wetland/ estuary	Specific site	Other	Kentucky	4.05–8.78

[1] Multiple WTP estimates from a single study were available due to in-study variation in such factors as elicitation methods and statistical analysis.

[2] Water body type can include: river/stream, lakes, wetlands/estuaries or all water resources combined.

[3] All values were adjusted for inflation to the 2010 US dollar value according to the Consumer Price Index.

Table 2. Description of meta-analysis variables.

Variable Category	Level	Description	Mean (SE)
Willingness to pay (dependent)	Ln_WTP	Natural log of willingness-to-pay to maintain or protect water resources, in 2010 US Dollars	3.01 (0.710)
Survey method	CV_ALL	1 if reference WTP was estimated using a survey instrument, including payment card, dichotomous choice, iterative bidding and attribute-based choice experiment; 0 otherwise.	0.772 (0.116)
Survey method	CV_OE	1 if WTP was estimated using an open-ended survey instrument; 0 otherwise.	0.166 (0.241)
Year	YR_INDX	Index of year the study was conducted (1970 baseline).	24.67 (6.080)
Weighting	RR_COFF	Weighting variable, calculated as response rate divided by sample size.	0.186 (0.174)
Median household income	INCOME	Median household income of respondents as reported by the original study or calculated from US Census data (2010 dollars).	50,605 (5,074)
Region	SOUTH	1 if the study was conducted in the southern region of the US (Tennessee, North Carolina, South Carolina, Georgia, Alabama, Mississippi, Louisiana, and Florida); 0 otherwise.	0.333 (0.304)
Resource	RIVER	1 if protected resource is a river; 0 otherwise.	0.388 (0.315)
Scale	ST_WD	1 if reference WTP for resource protection is statewide; 0 otherwise.	0.052 (0.007)
Scale	DR_BSN	1 if resource protection is within a drainage basin; 0 otherwise.	0.722 (0.289)
Scale	SGL_SITE	1 if resource protection at a single site; 0 otherwise.	0.221 (0.268)
Program	PRG_AE	1 if the proposed water quality protection program uses acquisition or easement type strategies implemented by a government agency; 0 otherwise.	0.389 (0.315)

Table 3. Estimated multiple regression model of water protection valuation function (dependent variable is natural log of annual value per individual).

Variable category	Level [1]	Coefficient (SE)
Intercept	Intercept	-0.883 (0.886)
Survey Method	CV_OE	-0.591** (0.220)
Year	YR_INDX	0.091*** (0.012)
Weighting	RR_COFF	0.897** (0.388)
Median household income	INCOME	0.058*** (0.000)
Region	SOUTH	-0.414 (0.259)
Resource	RIVER	-1.072*** (0.209)
Scale	DR_BSN	0.821** (0.340)
Scale	SGL_SITE	-1.294*** (0.415)
Program	PRG_AE	-2.990*** (0.209)
Sample size		43

Variable category	Level [1]	Coefficient (SE)
R^2 adjusted		0.8847
Standard error		0.246
F-statistic (degrees of freedom)		28.136* (9)
[1]Levels within each variable category were systematically compared against a corresponding reference variable to calculate a regression coefficient. *** Significant at p < 0.01 ** Significant at p < 0.05 * Significant at p < 0.10		

Table 4. List of regions in Florida and counties included in each region.

Region in Florida	Florida Panhandle	North Florida	Central Florida	South Florida
Counties in Each Region	Bay	Alachua	Brevard	Broward
	Calhoun	Baker	Citrus	Charlotte
	Escambia	Bradford	Hardee	Collier
	Franklin	Clay	Hernando	DeSoto
	Gadsden	Columbia	Highlands	Glades
	Gulf	Dixie	Hillsborough	Hendry
	Hamilton	Duval	Indian River	Lee
	Holmes	Flagler	Lake	Martin
	Jackson	Gilchrist	Manatee	Miami-Dade
	Jefferson	Levy	Okeechobee	Monroe
	Lafayette	Marion	Orange	Palm Beach
	Leon	Nassau	Osceola	Saint Lucie
	Liberty	Putnam	Pasco	Sarasota
	Madison	Saint Johns	Pinellas	
	Okaloosa	Union	Polk	
	Santa Rosa	Volusia	Seminole	
	Suwannee		Sumter	
	Taylor			
	Wakulla			
	Walton			
	Washington			

Table 5. Annual household Willingness to Pay (WTP) values (2010 USD) for two water-quality maintenance-protection programs that protect all water resources in the Florida Panhandle, north Florida, central Florida, and south Florida.

		Program that uses acquisition or easement-type strategies		Nonspecific Program	
Region	**Households**	**Annual WTP**	**Total WTP**	**Annual WTP**	**Total WTP**
Florida Panhandle	515,617	$3.32	$1,714,034	$64.81	$33,417,694
North Florida	927,333	$4.49	$4,162,010	$87.96	$81,564,757
Central Florida	1,519,000	$4.79	$7,279,996	$94.01	$142,802,599
South Florida	860,905	$4.57	$3,933,155	$89.56	$77,099,751

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