Valuing Ecosystem Services from Private Forests

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In addition to timber and other marketable wood products, Georgia's forests provide essential ecosystem services like water filtration, carbon storage, wildlife habitat, recreational opportunities and scenic beauty. The loss of forestland can lead to risks to human health, accelerated climate change, increased watershed disruption, loss of water quality, and loss of biodiversity (Pearce 2001). However, because no market exists in which to trade many of these services, landowners have little incentive to consider their value when making land use decisions. Recently, market-based mechanisms (such as the carbon registry or nutrient trading programs) have been proposed and/or designed in order to provide the landowner with greater incentives to leave land in forest production. Landowners who only consider the timber value of land in forest production will be more likely to choose non-forest land use options, such as development, which provide more benefits *to the landowner*. This means fewer acres in forest production, reduced importance of the region in global forest markets, and loss of benefits to society from reduced flows of ecosystem services. Efficient land use decisions must take into account the total economic value of each land use option, including market and non-market, use and non-use, values. If the total economic value of forested land, including the value associated with timber production *and* the other ecosystem services provided, is compared to the total economic value of alternative land uses, it is likely that more land would remain in forest production, ensuring sustainable flows of essential forest ecosystem services. We cannot address this problem without knowing the total economic value of forested land, including the value of all non-market forest ecosystem services.

Though the forest land use decision clearly indicates a failure of the market to lead to an efficient solution, historically, forest regulations and tax policies have not addressed this problem. One reason for this oversight is that the value of these other ecosystem services is difficult to quantify, even if the physical nature of the service is well-understood. While carbon markets and water quality trading markets may eventually help us quantify the value of these services, most of these institutions are still in the proposal or early development stage. Also, values of other forest benefits (*e.g.*, scenic beauty, habitat for endangered species) are less easily captured in market-like settings. As a result, it is difficult to incorporate these values into public decision-making in a meaningful way. At the same time, important decisions are being made today that will significantly impact the amount of land that remains in forest cover in the near future. The primary objective of the research summarized in this paper was to fill this knowledge gap by using best available methods to quantify the benefits Georgia's private forests provide to non-forest owners.

Defining ecosystem services

While sometimes unrecognized by humans, ecosystem services are a vital component of the ecology and economy of the world. The idea of ecosystem services has become an organizing principle for much recent research in both ecology and economics, and also appeals to land managers and landowners who are trying to make efficient decisions related to their land (Brown et al. 2007). As the field has developed, the definition of ecosystem services has evolved and several lists and organizational frameworks for evaluating ecosystem services have been developed (Costanza et al. 1997; de Groot et al. 2002; Daily 1997; MEA 2005; Brown et al. 2007; Boyd and Banzhaf 2006; Wallace 2007; Fisher and Turner 2008). In an early writing on the topic, Daily (1997) described ecosystem services as the "conditions and processes through which natural ecosystem, and the species that make them up, sustain and fulfill human life". The Millennium Assessment (MEA 2005) defines ecosystem services as the benefits people obtain from ecosystems and divides these services in to four categories: supporting, regulating, provisioning, and cultural services. Brown et al. (2007) distinguish between ecosystem structure, ecosystem processes, and ecosystem goods and services. Ecosystem structure includes the physical and biological components of the ecosystem itself, such as the quantity of water in a reservoir, the soil characteristics, or the density of trees. Ecosystem processes (also called ecosystem functions) are the things that link the components of structure. For example, water supply and wildlife growth are ecosystem functions that depend on the underlying ecosystem structure. Ecosystem processes support the production of ecosystem goods and services. Fisher and Turner (2008) distinguish between intermediate and final ecosystem services and their benefits. The human benefits flow from the final services, which are produced by intermediate services. In some cases, what is considered an intermediate service by Turner et al. is identified as an ecosystem process in Brown et al., and might be a regulating service in the Millennium Assessment.

A distinction can also be made between ecosystem goods and ecosystem services (Daily 1997; Brown et al. 2007). Ecosystem goods are the tangible products of nature, such as timber, minerals, water, and wildlife. Ecosystem goods are better recognized for their contribution to our "natural wealth". Ecosystem services are less recognized aspects of nature's services and in most cases refer to improvements in the condition or location of things of value. Daily referred to ecosystem services as the "actual life-support functions, such as cleansing, recycling, and renewal, …[which] confer many intangible aesthetic and cultural benefits as well (Daily 1997)".

The common thread of the ecosystem service literature is that any delineation, taxonomy, or classification system needs to be flexible and the most appropriate approach for evaluating (and valuing) ecosystem services depends on the needs and purpose of the project. This is not to imply that anything goes, but only to recognize that the distinction between these dichotomies (ecosystem process vs. ecosystem service, intermediate vs. final service, ecosystem good vs. ecosystem service) depends on the context of the problem at hand. Any attempt to evaluate ecosystem services must consider these issues if only to determine the scope of the project. For our purposes, we define **ecosystem services as the things nature provides that are of direct benefit to humans**. We recognize that these ecosystem services are dependent on underlying ecosystem structure and function that may or may not be recognized by society. We acknowledge the distinction between ecosystem goods and ecosystem services, but for brevity, in this report we will refer to these collectively as ecosystem services.

We identified eight broad classifications of ecosystem services provided by forestland in Georgia: timber and forest product provision, recreation, gas and climate regulation, water quantity and quality, soil formation and stability, pollination, habitat refugium, and aesthetic, cultural and non-use values. These ecosystem services are described in **Error! Reference source not found.**. However, because our objective is to estimate the public benefits of forestland, our estimated benefits do not include the value of timber and fiber provision or recreation.

Methodology

The best approach to valuing ecosystem services depends on the scale of the study area, data availability, time and budget constraints. For this project, we are interested in a statewide analysis of ecosystem services and determined that an approach similar to the spatially explicit value transfer approach described in Troy and Wilson (2006) and used by others conducting similar research (e.g., Liu et al. 2010) to be a useful starting spot. Adapting their approach, we outlined a four-step process for estimating the public ecosystem service benefits of private forests in Georgia: 1.) Identify the geographic, ecological and economic scope of the study; 2.) Create a landscape classification system based on forest characteristics which predict significant differences in the flow and value of ecosystem services; 3.) Use the best available data to estimate average per-acre values for each unique combination of forest characteristics and each ecosystem service identified; and 4.) Calculate the total ecosystem service value.

Step 1: Identify the geographic, ecological and economic scope of the study

We are interested in the ecosystem services provided by privately-owned forestland in Georgia. In addition, we are interested only in those ecosystem services that provide external benefits, or benefits that are enjoyed by individuals that do not own or use the forestland and therefore have limited or no influence on land-use decisions. Because of this, we are not considering the value of timber and forest product provision or recreation. Timber and other forest products provide value to those who use them, but this value is captured in the market exchange of these products. The value of this service is generally a private value shared by the landowner and the consumer. Other research adequately captures the importance of the timber industry in Georgia (e.g., Riall 2010). Similarly, recreation benefits are an important aspect of the benefits provided by forests (GFC 2008), but they are largely private benefits enjoyed by users of the resource – someone with access to the land. It is likely that many private forests provide recreational opportunities to the public, but our research is focused on those services that do not require land access.

Step 2: Create a landscape classification system based on forest characteristics which predict significant differences in the flow and value of ecosystem services.

There are over 22 million acres of forestland in Georgia and each acre is different. Georgia's forests are ecologically diverse, and are located in areas that are very socially diverse, meaning each acre of forest could have a unique value. For example, forests in riparian areas provide greater water quantity and quality benefits than forests farther from surface water. Similarly, urban forests are expected to provide greater benefits per acre when compared to rural forests, given their relative scarcity. However, it is not feasible to identify the value of each individual acre of forest on such a large scale. Instead, we created a landscape classification system that divides the state's private forests into categories based on geographic, ecological, and demographic characteristics. While there may be significant differences in ecosystem service flows and values across categories, within each category forests are relatively homogenous and it is more reasonable to consider an average value per acre.

Step 3: Use the best available data to estimate average per-acre values for each landscape classification and each ecosystem service identified.

As described above, there are many different approaches for estimating the magnitude of environmental benefits, including market valuation, stated preference approaches, revealed preference approaches, and benefits transfer. The preferred approach depends on the type of resource being valued and whose values are being considered. Because values are resource, location, and population specific, it is always preferred to estimate values from data specific to the resource, location and population. However this is not always possible given time and budget constraints. We took two approaches in this project. First, we used value transfer methods to apply results of previous research to estimate preliminary per-acre values for most of the ecosystem services considered. This process and these values are reported in Part 3 of this report. Some ecosystem services, such as water quantity and quality, climate regulation and soil stabilization, are unrelated to the ownership classification of the land. Because of this, existing studies that consider the value of these benefits for either public (most commonly) or private (like our study is) forest lands are relevant to our current research. The primary determinants of the magnitude of these services are the biophysical properties of the forest ecosystem. However, the aesthetic and passive use value of forest land is much more sensitive to the preferences and values of the population and the ownership characteristics of the forest. For example, we would not expect the existence value of privately owned forests to be as large as that of national forests due to the expectations and assumptions people make about the management of these two types of forests. Because of this, value transfer is less reliable for these types of values. To address this, we collected original stated preference data specific to Georgia's private forests and used this data to estimate non-use benefits. Part 4 of this report describes the survey component the project and presents the results of this estimation

Step 4: Calculate the total ecosystem service value

The total ecosystem service value is estimated by multiplying the per-acre dollar value estimates for each landscape classification category by the number of forested acres of that type.

Landscape classification

There are over 22 million acres of privately-owned forestland in Georgia. The value of ecosystem services provided by a particular acre of forestland depends on the quantity and quality of the ecosystem functions and services provided, and the magnitude, preferences, and demographic characteristics of the population receiving those services, typically the nearby population. For large scale valuation projects such as this one, it is not possible to consider each parcel of forestland separately. Instead, we develop a landscape classification system that identifies forestlands that are likely to have similar per-acre values of ecosystem services. We then estimate the value of an average acre of forests in each unique category and apply this value to all acres in that category.

We considered seven different characteristics of forests expected to create differences in the flow and/or value of ecosystem services: **forest type, riparian status, rare species abundance, scenic visibility, public land buffer, development class, and geographic region**. Some of these characteristics primarily affect the quantity or quality of ecosystem services provided. For example, an acre of forestland in a riparian area has a much greater impact on water quality and quantity than an acre of non-riparian forest. The per-acre value of riparian forests will be higher because of this difference in the underlying ecosystem function. Other characteristics primarily affect the value of the service provided. For example, an acre of forestland in an urban area will have a greater aesthetic value than one in a rural area partly because more people are around to see it.

Geospatial data layers were obtained through the Georgia GIS clearinghouse (http://www.gis.state.ga.us/) and projected into a common coordinate system (UTM NAD83 Zone 17). Vector layers were processed to select the appropriate attribute values and converted to raster layers at 30m cell resolution. Table 1 summarizes the data source, relevant attributes, and processing notes for the eight data layers used. Combining the forest and public/private data layers, we identified 22,104,618 acres of privately-owned forestland in Georgia. This represents almost 60% of the total land area in the state. Considering the scale of the analysis, this is almost identical to the estimate of 24.2 million acres reported in the Forest Inventory Analysis (Harper et al. 2009), supporting the accuracy of our analysis.

Based on the seven forest characteristics identified above, we identified 864 possible combinations of characteristics that might describe Georgia's private forests. These characteristics define much of the important variation in ecosystem service flow and value. In applying this classification scheme, we move from an intractable problem (trying to evaluate each of the 22 million acres of private forests separately) to a complex, but manageable one. For a given combination of forest characteristics (eg., mixed forests in North Georgia, riparian, high wildlife, non-roadside, non-public buffer, and urban), we assume each acre of forest with those characteristics produces an identical flow of ecosystem service value. However, forests with different characteristics can have different per-acre values. This is an improvement over most previous studies of this type that allow for just a few different types of forests (and often consider all forest acres as identical).

Not all classes are equally represented by Georgia's private forests. For example, there are no private forests in Georgia that are characterized as riparian, with low species abundance, are visible from a highway, buffer public land, and are in an urban area of south Georgia. Of the 864 potential classes of forests, 65 include no private forestland in Georgia, and an additional 547 classes describe fewer than 1000 acres each. In contrast, over 12% of all forests in Georgia fall in a single class (rural, south Georgia, evergreen, not riparian, not roadside, not public buffer, low wildlife).

Table 1. Summary of GIS Data Sources

Layer	Source, Date & Scale	Attributes	Processing
Private/ Public Land	Georgia Gap Stewardship layer, NARSAL, 2003, 1:24,000	Owner_code	All federal, state, county, DNR, and DOD_COE lands coded as Public, all other lands within state boundaries coded as Private; converted to 30m raster
	Georgia Department of Natural Resources (DNR) lands, 2009, 1:24,000	Owner_code	
	Department of Defense, Army Corps of Engineers (DOD_COE) lands; Georgia Natural Heritage Program, 2005, 1:24,000	Owner_code	
Forest Type	2005 GLUT (Georgia Land Use Trends), NARSAL, 2005 1: 100,000	Deciduous (41), Coniferous (42) and regenerating (31), Mixed (43), Forested Wetland (91)	
Riparian Status	DLG hydrography polygons and lines, 1996, 1:100,000	Major1	Converted to 30m raster, included 30 m (1 pixel) adjacent to water
Rare Species Abundance (Rare Species Records)	USGS 1:24,000 quarter quad	Showing number of spp (animal, plant) that are in that quad that are of conservation concern (R, T, E)0-5: Low; 6-11: Medium; >11: High	Converted to 30m raster
Scenic Visibility (Major Roads)	Georgia DOT, 1996, 1:100,000	Type = interstate, ramp, state highway, collector-distributor, county roads	Converted to 30m raster
Public Land Buffer		90 m (3 pixels) surrounding all public lands	
Development Status	Wildlands-Urban Interface, 2000 Census Blocks, 1:24,000	HDEN00 = housing density per km2 in 2000	1) Urban (>120 units per km2), 2)suburban (25-120 units/km2), 3) rural - exurban put into rural (<25 units/km2); converted to 30m raster
GA Regions	Georgia Counties		Converted to 30m raster

Value Transfer

The third step of our approach is to use best available methods to estimate average per-acre values for each category of forestland identified by a unique combination of characteristics. In general, the best available approach is through a combination of methods that rely on data specific to the study area and research question. This might be done in a piece-wise manner, estimating separate values for each ecosystem service provided, using the appropriate methods from those described in Part 1 of this report. Time and budget constraints often limit our ability to collect original data for all aspects of ecosystem services. An alternative approach is to use value transfer methods to apply estimates from previous studies to the current study. Value transfer is inferior to original data collection, but is a common and acceptable alternative (Liu et al. 2010).

We take a two-pronged approach to estimating per-acre ecosystem service values. We developed a stated choice survey to collect original data to estimate aesthetic and non-use values of our study area. Relative to other ecosystem services, these values are most dependent on the tastes and preferences of the local population and therefore the most problematic for value transfer. For the other ecosystem services of interest which are relatively less dependent on the tastes and preferences of the local population, we relied on transferred values. This part of the report describes the value transfer procedures and results, while Part 4 describes the survey methods used to estimate aesthetic and non-use values.

General Value Transfer Protocol

Consistent with the standard practice for value transfer, we considered only published, peer-reviewed literature in our search. Our initial review of the literature identified two general types of studies that we might consider: those with original analysis and those that conduct value transfer and synthesize other reports. The study most similar to ours is that by Liu et al. (2010) who estimated the ecosystem service values of New Jersey's different ecosystems. This paper considers a similar geographic region to Georgia and provides per-acre value estimates broken down by ecosystem service. Other examples of this type of study are Costanza et al. (1997) and Troy and Wilson (2006).

For each ecosystem service considered, we began with a preliminary estimate of the per-acre value based on the values reported in Liu et al. (2010). We then carefully considered the sources used to generate that value. We removed some source estimates, reestimated others to better apply to the population and area of Georgia, and considered other original studies identified that were relevant. These original studies were identified though the ENVI and EconLit databases. From this process, we estimate the average per-acre value of each service by forest characteristics and also identify areas of much needed research. Table 2 summarizes these values. Appendix A provides a list of all studies used in our value transfer analysis.

Table 2. Summary of Value Transfer Analysis

Ecosystem Service	**$/acre/year in 2009 US$**
Gas and climate regulation: These estimates are based primarily on studies looking at carbon storage and avoided climate change damages. The studies of urban forest values also consider other pollutants.	$381 for urban forests $28 for other
Water regulation and supply: Includes flood damage protection, water quality improvements, and impacts on water supply	$8,196 for urban and suburban forested wetland $4,635 for rural forested wetland $1,728 for riparian, non-wetland $7 for non-riparian, non-wetland urban $0 for non-riparian, non-wetland rural and suburban (due to lack of available data)
Soil formation: While some information is available, it is very case specific and not reliably applied to our project	No data available
Pollination:	$184 for non-wetland forests

This estimate is based on a single study from Sweden.	$0 for wetland forests (due to lack of available data)
Habitat/refugia: These estimates are based on studies using stated value methods, with most looking at biodiversity in general in relatively diverse areas.	$251 for evergreen forests in Middle and South Georgia with middle or high rare species abundance; $223 for other forests with middle and high rare species abundance; $28 for evergreen forests in Middle and South Georgia with low rare species abundance; $0 for other low rare species abundance
Aesthetic and Non-use value	Estimated with stated choice study below

As the above discussion illustrates, all forests are not equal. That is, they do not necessarily produce the same flow of ecosystem service values. Per-acre values range from $212 to $8,800/year depending of the characteristics of the forest. Because of this variation in per-acre value, it is not always clear *a priori* which class of forest produces the greatest value of ecosystem services. Table 3 through Table 5 present the number of acres, the average per-acre value, and the total value of each combination of forest characteristics. As the tables show, despite the fact that forested wetlands comprise only 16% of all private forestland in Georgia, they provide 66% of the value of the ecosystem services considered so far (not including Aesthetic and Non-use). This reflects the vital role wetlands play in the maintenance of healthy watersheds.

Table 3. Estimated values for Evergreen Forests by forest characteristics, without aesthetic.

Rare Species Abundance	Riparian Status	Development Status	Region	Acres	$/acre/year	Total Value ($/year)
Low Rare Species Abundance	not riparian	urban	N	83,878	572	47,978,216
			M & S	21,244	600	12,746,400
		suburban & rural	N	1,372,430	212	290,955,160
			M & S	5,725,491	240	1,374,117,840
	riparian	urban	N	9,139	2,293	20,955,727
			M & S	2,092	2,321	4,855,532
		suburban & rural	N	96,252	1,940	186,728,880
			M & S	526,922	1,968	1,036,982,496
Mid and High Rare Species Abundance	not riparian	urban	N	30,328	795	24,110,760
			M & S	35,344	823	29,088,112
		suburban & rural	N	512,626	435	222,992,310
			M & S	3,114,401	463	1,441,967,663
	riparian	urban	N	3,142	2,516	7,905,272
			M & S	4,321	2,544	10,992,624
		suburban & rural	N	43,031	2,163	93,076,053
			M & S	349,229	2,191	765,160,739
All Evergreen Forests				**11,929,870**		**5,570,613,784**

Table 4. Estimated values for Deciduous and Mixed Forests without aesthetic.

Rare Species Abundance	Riparian Status	Development Status	Acres	$/acre/year	Total Value ($/year)
Low Rare Species Abundance	not riparian	urban	75,801	572	43,358,172
		S & R	3,690,483	212	782,382,396
	riparian	urban	13,467	2,293	30,879,831
		S & R	507,407	1,940	984,369,580
Mid and High Rare Species Abundance	not riparian	urban	44,409	795	35,305,155
		S & R	1,975,879	435	859,507,365
	riparian	urban	7,021	2,516	17,664,836
		S & R	268,106	2,163	579,913,278
All Deciduous and Mixed Forests			**6,582,573**		**3,333,380,613**

Table 5. Estimated values for Forested Wetlands by forest characteristic, without aesthetic.

Rare Species Abundance	Riparian Status	Development Status	Acres	$/acre/year	Total Value ($/year)
Low Rare Species Abundance	not riparian	urban	7,176	8,577	61,548,552
		suburban	33,059	8,224	271,877,216
		rural	971,481	4,663	4,530,015,903
	riparian	urban	6,918	8,577	59,335,686
		suburban	28,952	8,224	238,101,248
		rural	1,001,060	4,663	4,667,942,780
Mid and High Rare Species Abundance	not riparian	urban	6,938	8,800	61,054,400
		suburban	27,639	8,447	233,466,633
		rural	723,975	4,886	3,537,341,850
	riparian	urban	4,354	8,800	38,315,200
		suburban	23,194	8,447	195,919,718
		rural	757,428	4,886	3,700,793,208
All Forested Wetlands			**3,592,174**		**17,595,712,394**

In addition to the value estimates presented, this section of the analysis identifies several areas where additional research is needed, either to better understand the ecological production of an ecosystem service, the economic value of that service, or to create links between these two areas. Where we were unable to find information, we were forced to apply a value of $0/acre. This leads to a conservative estimate of the total value of the forested land but in certain locations where these other values are significant, this omission could have important policy implications.

Stated Choice Experiment

Value transfer for aesthetic, cultural, and non-use values is more problematic because these values depend on both the characteristics of the resource itself and the tastes and preferences of the population. Instead, we base our estimates of aesthetic and non-use values on analysis of data collected specifically for this study using a stated choice approach. This section describes the survey instrument and administration, presents summary data from the survey, and provides the estimated aesthetic and non-use value of Georgia's private forests.

Survey Design and Administration

We conducted a mail survey of the general population of Georgia during summer and fall 2010. The survey contained background information on forests and ecosystem services and asked respondents about their familiarity with Georgia's forests, recreation activities, general questions about the environment, preferences for public regulation of forested land, and sociodemographic characteristics. In addition, each respondent was asked four questions as part of the stated choice experiment. In these questions, the respondents were invited to participate in a hypothetical referendum. They were told that a referendum was up for vote that would affect the future of Georgia's private forests. They were presented with two alternative futures in each question. Each alternative was described in terms of the gain or loss of forest area in each of the three Geographic Regions in the state. In addition, each region was assigned one of four possible Public Priorities: Wildlife, Scenic Views, Water Quality and Quantity, or No Public Priority. If a Public Priority was identified for a particular region, that meant that future land use planning would place higher priority on protecting forested land that was most important for that goal (e.g., if Scenic Views is a priority, forests along roads would be considered a greater conservation priority than other forests). The survey emphasized that we were only considering private forest land, and that private landowners would still have decision-making authority regarding their land. Regardless of their selection, respondents would not have access to additional forestland in the future.

The basic premise of conjoint analysis is that while each question is a "simple" comparison between two or more alternatives, by asking many different questions with different combinations of attributes for each option, the analyst can apply standard discrete-choice modeling techniques to estimate the marginal value of the various attributes. In our survey, each alternative (or a possible future state of Georgia's forests) was defined by seven different attributes: Forested Acres and Public Priority in each of the three Geographic Regions (6 attributes total), plus the cost of the option to the household in terms of estimated increase in the price of wood products, taxes, utilities, and other expenses. The six regional attributes were allowed to take on one of four possible values (called attribute levels in the conjoint literature), and the cost attribute was assigned one of eight values. Table 66 summarizes the attributes and attribute levels used in our survey.

With six 4-level attributes and one 8-level attribute, there are 32,768 ($= 4^6 \cdot 8^1$) possible combinations of attributes, or alternatives. Our survey presented a choice between two alternatives creating over 1 billion possible questions. (This would be a full factorial design). Because it isn't possible to ask this many questions, the conjoint analysis literature provides guidance in identifying which subset of these questions should be asked in order to most efficiently estimate the model of interest (these subsets are known as fractional factorial designs; see Louviere, Henshcher and Swait (2000) for an introduction to experimental design). We used the software program NGENE to create an orthogonal main-effects experimental design that required only 32 different choice questions (64 distinct profiles). These 32 questions were blocked into 8 groups so that each survey respondent was asked four different choice questions. As a result, there were 8 different versions of the survey instrument. These versions were identical except for the stated choice questions themselves.

Table 6. Attributes and levels for stated choice experiment.

Attribute	Levels
North Georgia Acres	-2%, no change, +2%,+5%
North Georgia Priority	Wildlife, Scenic, Water, No Priority
Middle Georgia Acres	-2%, no change, +2%,+5%
Middle Georgia Priority	Wildlife, Scenic, Water, No Priority
South Georgia Acres	-2%, no change, +2%,+5%
South Georgia Priority	Wildlife, Scenic, Water, No Priority
Cost (per year to household)	\$0, \$10, \$25, \$50, \$75, \$100, \$200, \$500

A sample of 3100 names and addresses was purchased from Survey Sampling, Inc. A pretest subsample of 100 was randomly selected from the purchased list. The pretest group was mailed a preliminary version of the survey. Some questions were revised based on the pretest responses. The final sample of 3000 was stratified by Geographic Region, so that 1000 surveys were sent to each of the three regions: North, Middle, and South Georgia. This was done to provide adequate coverage outside the metro Atlanta area. Within each region, each recipient was randomly assigned one of the eight versions of the survey so that each version was stratified by region as well. Following a modified Dillman method (Dillman 2006), we made three contacts: the initial mailing including cover letter and survey, a follow-up thank you/reminder postcard to everyone, and a third mailing to non-respondents including another copy of the survey. A fourth contact (third survey mailing) was not done because the effect of the second mailing was minimal.

Table 7 shows the sample size, non-deliverables and response rate by Geographic Region. Overall, the response rate was 28%. We found no significant difference in response rate across regions, or across the eight versions of the survey.

Table 7. Response Rate by Region.

Region	Mailed	Undeliverable	Returned	Response Rate
North Georgia	1000	72	270	29%
Middle Georgia	1000	88	262	29%
South Georgia	1000	72	248	27%

Summary of Survey Data

In addition to the questions related to the choice experiment, the survey gathered data on respondents' experiences with forestland in Georgia, general attitudes about forests and the forest industry, and basic demographic data. Table 8 and Table 9 describe the respondents and their experience with Georgia's forests. Respondents from the three regions are similar in age and gender composition, but respondents from middle and south Georgia are more likely to be from rural areas, and report slightly lower median education and income levels. In addition, respondents from the different regions have different rates of forest ownership and different rates of participation in different forest-related recreation. These differences support our decision to estimate different WTP values for residents in the three different regions.

Table 8. Sociodemographic characteristics of the survey respondents by Region.

Characteristic	North Georgia	Middle Georgia	South Georgia
Mean Age	55 years	57 years	55 years
Percent female	36%	36%	36%
Development Status of "area where respondent grew up"	44% Rural 40% Suburban 16% Urban	56% Rural 33% Suburban 11% Urban	65% Rural 23% Suburban 11% Urban
Median education level	Bachelor's degree completed	Some college or tech school	Some college or tech school
Median income category	$60,000 to $69,999	$50,000 to $59,999	$50,000 to $59,999

Table 9. Experience with Georgia's forests by Region.

	North Georgia	Middle Georgia	South Georgia
% who own at least 1 acre of land with some tree cover in Georgia	36% (median 2 acres)	38% (median 3 acres)	44% (median 5 acres)
% of landowners who carry our regular thinning, pruning, or planting	10%	14%	17%
Visited public forests in past 12 months	60%	47%	49%
Not visited any forests in past 12 months	27%	37%	36%
Often hunt in Georgia	8%	21%	23%
Often hike, bike or camp in Georgia	24%	16%	20%
Often bird or wildlife watch in Georgia	19%	18%	18%
Often fish in Georgia	14%	18%	31%
Often swim or boat in Georgia	14%	19%	26%
Often drive through large forested areas	42%	45%	48%

Overall, respondents reported changes in the landscape in their area. 63% of respondents feel the beauty of the landscape in their area has changed over the years due to tree cutting. 34% of respondents thought the area devoted to pine forests in their local area is decreasing, and 40% reported the area devoted to hardwood forests is decreasing. These rates are much lower than those reported in a 1997 telephone survey of Georgia residents in which 54% thought pine coverage was decreasing and 63% thought hardwood forests were decreasing (Harrison, Newman and Macheski 1997). In addition, 65% of respondents have concerns or apprehensions about the way forests in Georgia are being managed. The most frequently identified concern is loss of wildlife habitat (47% of all respondents).

Respondents were mixed in their view of private property rights. Only 45% of respondents agreed with the statement "I trust Georgia's forest owners to maintain healthy forests in the long term." When asked if they agree that there are enough checks and balances in place to ensure responsible forest management in Georgia, 24% of respondents agreed, 45% were neutral, and 27% disagreed. Only 28% of respondents felt that private forest owners have the right to do as they please with their forests regardless of what it does to the environment. 58% said private property rights should be limited if necessary to protect the environment but 68% said that the landowner should be paid for any economic loss accrued when prevented from cutting on his land because of government regulations.

When asked about different types of compensation programs, only 41% would support a program that required forest landowners to comply with regulations designed to provide benefits for the public. But 55% would support a program that provided tax-funded incentives for forest landowners to voluntary comply with such regulations and 58% would support a non-tax funded incentive.

Aesthetic and Non-Use Value Estimates

The economic theory underlying the stated choice method is the Random Utility Model (RUM), where utility is assumed to consist of two components, so that utility individual *i* receives by choosing (or consuming) alternative *j*, is given by

$$U_{ij} = V_{ij}(x_j;\beta) + \varepsilon_{ij}$$

where V_{ij} is the deterministic portion of utility based on a vector of alternative specific attributes X_j and preference parameters β; and ε_{ij} is the random component of utility, known to the respondent but unobservable by the analyst. Faced with a choice between two (or more) alternatives, the respondent chooses alternative j if and only if the utility of doing so is greater than the utility of any other option in their choice set. Assuming ε_i is a randomly distributed across alternatives with a Gumbel distribution with scale parameter equal to 1, we can model the probability of choosing alternative j with a standard multinomial logit model (MNL), so that

$$\begin{aligned}\Pr\left(\text{choosing alternative } J \mid \text{choice set } C\right) &= \Pr\left(U_j > U_k; k \in C, k \neq j\right) \\ &= \Pr\left(V_j + \varepsilon_j > V_k + \varepsilon_k; k \in C, k \neq j\right) \\ &= \frac{e^{V_j}}{\sum_{k \in C} e^{V_k}}\end{aligned}$$

For our data, we are interested in the marginal value of an acre of forested land and how this value depends on the characteristics of the forest. We model the deterministic part of utility as follows

$$\begin{aligned}V_j = {} & \beta_1 AreaNG_j + \beta_2 AreaMG_j + \beta_3 AreaSG_j \\ & + \beta_4 WildNG_j * AreaNG_j + \beta_5 WaterNG_j * AreaNG_j + \beta_6 RoadNG_j * AreaNG_j \\ & + \beta_7 WildMG_j * AreaMG_j + \beta_8 WaterMG_j * AreaMG_j + \beta_9 RoadMG_j * AreaMG_j \\ & + \beta_{10} WildSG_j * AreaSG_j + \beta_{11} WaterSG_j * AreaSG_j + \beta_{12} RoadSG_j * AreaSG_j \\ & + \beta_y Cost_j\end{aligned}$$

where the variables *AreaNG*, *AreaMG*, and *AreaSG* are the percent change in forestland in North, Middle, and South Georgia, respectively, and the Public Priority for each region is effects-coded into three variables per region as described in Table 10.

Table 10. MNL variable names and descriptions.

Variable name	**Description**
AreaNG, *AreaMG*, *AreaSG*	Percent change in forest land in North, Middle, and South Georgia respectively
WildNG, *WildMG*, *WildSG*	= 1 if wildlife is the regional priority = -1 if there is no regional priority = 0 otherwise
WaterNG, *WaterMG*, *WaterSG*	= 1 if water is the regional priority = -1 if there is no regional priority = 0 otherwise
RoadNG, *RoadMG*, *RoadSG*	= 1 if scenic roads are the regional priority = -1 if there is no regional priority = 0 otherwise

Using this specification and variable coding scheme, an individual's marginal willingness to pay (WTP) for a 1% increase in forest area can be estimated from the coefficients. For example, individual *i*'s marginal WTP for a 1% increase in forestland in North Georgia with priority on wildlife protection is simply

$$\text{marginal WTP}_{\text{i}}(\text{north GA, wildlife}) = \frac{\beta_1 + \beta_4}{\beta_y}$$

where the coefficient on the cost variable, β_y, is the marginal utility of income. The use of effects coding with No Priority as the baseline, means that under no public priority, individual *i*'s marginal WTP for forestland in North Georgia is given by

$$\text{marginal WTP}_i(\text{north GA, no priority}) = \frac{\beta_1 - \beta_4 - \beta_5 - \beta_6}{\beta_y}$$

Because we expect individual tastes and preferences related to forest benefits to vary by region, we estimated separate MNL models for individuals living in each geographic region. All regressions were run using Limdep 9.0 and NLOGIT 4.0.

Table 11. Individual Marginal WTP by region and priority.

Geographic Region where forestland is added	Priority	Marginal WTP for individual living in North GA ($/year)	Marginal WTP for individual living in Middle GA ($/year)	Marginal WTP for individual living in South GA ($/year)
North GA	No Priority	15	0	0
	Wildlife	39	0	0
	Water	50	26	31
	Roads	17	10	16
Middle GA	No Priority	11	19	7
	Wildlife	35	30	7
	Water	35	16	6
	Roads	25	30	12
South GA	No Priority	6	3	0
	Wildlife	0	26	33
	Water	14	10	30
	Roads	0	6	3

Table 11 shows the marginal WTP for different priorities for individuals living in each region. Each column represents an "average" person living in north, middle or south Georgia. For example, we estimate that an individual living in north GA would be willing to pay $15/year for an increase in forestland in north GA, but only $11/year for an increase in middle GA and only $6/year for an increase in south GA. We make two important observations from this table. First, individuals report a positive WTP for forestland across the state, but do have a higher WTP for forestland in their own geographic region. Second, people generally pay a premium for water and wildlife priorities. The effect of prioritizing forested roads was less clear.

The values given in Table 11 are $/household/year for a 1% increase in area. To incorporate this information into our larger analysis, we need to convert these values to $/acre/year. We do this in three steps. First, divide each value by the number of acres represented by a 1% increase in forested area for that region to get $/household/acre/year. Then, multiply by the estimated number of households in the region based on 2009 census population estimates and the 2000 census estimate of 2.65 persons per household in Georgia. Finally, sum the value of land from residents of all regions.

Table 12 reports the estimated value of forestland to the residents of Georgia based on forest characteristics. To be as conservative as possible in our estimates, we assumed a Wildlife Priority would only apply to forests included in the High Rare Species category, which is just 7% of all forested land. The per-acre values range from $52/year to $4,642/year depending on the forest characteristics. The total aesthetic and non-use value of Georgia's private forests to the residents of Georgia is almost $11.2 billion/year.

Table 12. Aesthetic and non-use value estimates.

Region	Characteristics	$/acre/year	Acres	Value ($/year)
North Georgia	Riparian	642	4,336,704	2,782,690,720
	Road-buffer	1,695	347,053	588,153,579
	High Wildlife	4,642	708,310	3,287,634,733
	Other	1,882	401,315	755,283,923
Middle Georgia	Riparian	314	5,365,262	1,686,716,322
	Road-buffer	617	278,900	172,207,936
	High Wildlife	481	846,600	407,601,487
	Other	577	336,134	193,850,627
South Georgia	Riparian	54	6,416,865	347,061,827
	Road-buffer	371	855,451	317,690,719
	High Wildlife	342	1,825,377	624,866,608
	Other	52	386,649	20,255,257
		TOTAL	**22,104,618**	**11,184,013,738**

Final Estimates

There are 22.1 million acres of privately owned forestland in Georgia. Our analysis estimates that the value of ecosystem services provided by this land to the public is over $37.6 billion per year. Table 13 breaks this value down by ecosystem service.

Table 13. Total value by ecosystem service.

Ecosystem Service	Total Value ($/year)
Gas and Climate Regulation	744,446,192
Water Regulation and Supply	20,306,463,460
Soil Formation	N/A
Pollination	3,406,289,512
Habitat/refugia	2,042,507,627
Aesthetic and non-use	11,184,013,738
Total	**37,683,720,529**

The value of a particular acre of forest ranges from $264 to $13,442/acre annually. Higher per acre values generally come from forested wetlands or riparian forests in urban areas while lower per-acre values come from non-wetland forests in rural areas. Table 14. Impact of Forest Characteristics on Ecosystem Services summarizes our findings on how forest characteristics impact different ecosystem services.

Table 14. Impact of Forest Characteristics on Ecosystem Services

	Gas and Climate regulation	Water regulation and supply	Soil formation	Pollination	Habitat/refugia	Aesthetic and Non-use
Forest Type	X	X		X	X	
Rare Species Abundance					X	X
Riparian Status		X				X
Scenic Visibility			No Values Available			X
Public Land Buffer						
Development Status	X	X			X	
Geographic Region					X	X

An "X" indicates the per acre value of that ecosystem service will depend on the forest characteristic indicated.

Our analysis highlights the need for additional work in this area. There are significant gaps in our knowledge of both the impact of forest cover on the production of ecosystem services, and how these services are valued in the state. We were most constrained in our analysis by the lack of information related to non-carbon air quality services, soil formation and stability, and pollination. In developing future research related to forest ecosystem services, it will be important to take an interdisciplinary approach. A major challenge to this type of work is that the outputs of the ecological models (typically the results of ecosystem processes) rarely match up with the inputs to the valuation models (the ecosystem services). Natural scientists and economists must work together to address this issue.

Significant steps were taken to minimize potential error throughout all aspects of the research. However, due to the complexity of the analysis, there are several potential sources of error in the process. The most likely possible sources of error are measurement error in the creation of the GIS data layers, which we minimized by using standard data sets; estimation error in the original studies used in the value transfer, minimized by using only peer reviewed, published papers; error introduced in the transfer of values to our study, though every effort was made to be as conservative as possible in this process; and error due to sample selection bias in the stated choice survey, though our response rate is typical for this type of study.

These values in context

These estimates should be considered a lower bound estimate of the public value of private forests for three primary reasons. First, we faced significant data limitations in the value transfer part of our project. The value of some ecosystem services could not be explicitly included in our final estimates because there was not enough information available to estimate their value (for example, values of non-endangered but culturally valuable species), or because the benefits occur on a relatively small scale and could not be incorporated at the state-level (for example, values of erosion control and ground water recharge), and habitat for non-endangered, but culturally valuable species. Second, our assignment of forest characteristics is quite conservative. For example, only a 30m riparian buffer was considered and only 7% of all forests were considered High Rare Species Abundance. And third, our assignment of per-acre values was conservative. We applied values only to similar forest types so as not to overestimate values on dissimilar parcels. For example, the estimate of flood damage avoidance services from wetlands was only applied to urban and suburban forests, where flood damage is highest.

Not only should our estimates be considered a lower bound on the public value of private forests, they are only one component of the Total Economic Value of private forests in Georgia. We estimate the indirect use and non-use values of the forests. These are components of value that do not require ownership of or access to the land. Direct use value was not considered in our analysis. Two significant components of the direct use value of Georgia's forests are the value of timber and forest products and recreation. Other research estimates that the economic impact of forest products manufacturing in Georgia is approximately $27 billion per year and the industry related activity employs over 118,000 people (Riall 2010). The other component of direct use value that is significant is the recreation value. We did not consider recreation values because recreation requires access to the land and not all private land allows access. However, private forests play an important role in providing outdoor recreation opportunities in Georgia. Georgia has the most non-resident hunters of any state and these sportsmen spend $1.8 billion/year in the state. The economic impact of angling in Georgia is over $1.5 billion per year (GFC 2008).

As tempting as it is, it would be incorrect to add these estimates of the impact of the forest industry and forest recreation to our estimates of the non-timber benefits. The Total

Economic Value of Georgia’s private forests includes the direct use value, the indirect use value, and the non-use value. Our research estimates the indirect use value and non-use value to be approximately $37.6 billion/year. The direct use value includes the value of timber and forest products provision and recreation. However, economic impact and economic value measure two different things. The economic impact estimates we identify from the existing literature ($27 billion/year for forest products industry and $1.8 billion/year for recreation) trace the revenue generated by these industries through the state economy. They are not estimates of the total surplus, or total willingness to pay, for these services and so we cannot add them to the indirect use and non-use value we estimated. However, the magnitude of the economic impacts is an indication of how important the forest industry or forest recreation is to the state’s economy in terms of revenue and job creation. Georgia’s private forests provide the raw materials and location necessary to maintain these activities and best management practices help to ensure the sustainable harvest of this resource. So while we can’t simply add the impact of forest recreation and the forest industry to our estimate of the indirect use and non-use values of Georgia’s forests, when viewed together this body of research provides an overall view of the importance of forestland to the people of Georgia.

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