Quantifying the value of non-timber ecosystem services from Georgia's private forests

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Executive Summary

Georgia's forests provide essential ecosystem services like water filtration, carbon storage, wildlife habitat, recreational opportunities and scenic beauty. However, because no market exists in which to trade many of these services, it is difficult to quantify the benefits they provide. Ecosystem services are those things that nature provides that are of direct benefit to humans. The purpose of the research summarized in this report is to provide an estimate of the value of ecosystem services provided by private forests in Georgia.

We outline 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; 4) Calculate the total ecosystem service value.

Identify the geographic, ecological and economic scope of the study

The scope of our study is limited to the 22 million acres of privately-owned forestland in Georgia. Based on a review of the literature, we identified eight types of ecosystem services forests provide:

1. **Timber and forest product provision:** Forests provide raw materials for many uses.
2. **Recreation:** Forests provide a potential place for recreation.
3. **Gas and climate regulation:** Forests contribute to the general maintenance of a habitable planet by regulating carbon, ozone, and other chemicals in the atmosphere.
4. **Water quantity and quality:** Forests capture, store, and filter water mitigating damage from floods, droughts, and pollution.
5. **Soil formation and stability:** Forest vegetation stabilizes soil and prevents erosion.
6. **Pollination:** Forests provide habitat for important pollinator species who naturally perpetuate plants and crops.
7. **Habitat/refugia:** Forests provide living space to wild plants and animals.
8. **Aesthetic, cultural and passive use:** Forests provide scenic value and many people have a positive existence value for forestland.

We are interested only in those ecosystem services that provide external benefits, or benefits to people besides the landowner or land user. Because of this, we do not consider the value of timber and forest products provision or recreation. We do consider the value of the other six ecosystem services listed above.

Create a landscape classification system based on forest characteristics

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 forest characteristics 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 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 functions. 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 simply because more people are around to see it.

Based on our application of these seven characteristics, there are 864 possible combinations of characteristics that might describe Georgia's private forests. These characteristics describe 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 forest characteristics 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 classifications of forests, 65 include no private forestland in Georgia, and an additional 547 classifications describe fewer than 1000 acres each. In contrast, over 12% of all forests in Georgia fall in a single classification (rural, south Georgia, evergreen, not riparian, not roadside, not public buffer, low wildlife).

Use the best available data to estimate average per-acre values

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 five ecosystem services of interest we relied on value transfer methods.

For the value transfer component, we considered each ecosystem service individually. We began with a preliminary estimate of the per-acre value based on the values reported in a similar study in New Jersey (Liu et al. 2010). We then carefully considered the sources used to generate that value. We removed some source estimates, reevaluated others to better apply to Georgia, and considered other original studies that might be included. 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 1 summarizes the value estimates for the five ecosystem services considered for value transfer.

Table 1. Summary of ecosystem service values for value transfer.

Ecosystem Service	$/acre/year in 2009 US$
Gas and climate regulation:	$28 - $381 depending on forest characteristics
Water regulation and supply:	$0 - $8,196 depending on forest characteristics
Soil formation:	No data available
Pollination:	$0 - $184 depending on forest characteristics
Habitat/refugia:	$0 - $251 depending on forest characteristics

To estimate aesthetic and non-use values, 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 respondent was 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. By varying the attributes of the alternatives, we are able to estimate an individual's marginal willingness to pay (WTP) for an increase in different types of forestland. When aggregated to the population of Georgia, the aesthetic and non-use value of additional forested acres ranges from $52/year to $4,642/year depending on the characteristics and location of the land. We found that respondents expressed positive values for forest land across the state, but not surprisingly had higher values for forestland in their area. Also, respondents were willing to pay a premium to protect forests important for wildlife and water.

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. Respondents from different regions have different rates of forest ownership and different rates of participation in different forest-related recreation. A majority of respondents reported that the beauty of the landscape in their area has changed over the years due to tree cutting and have concerns or apprehensions about the way forests in Georgia are being managed.

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. Just over half of respondents would support programs that provided incentives for forest landowners to voluntarily comply with environmental regulations.

Calculate the total ecosystem service value

Based on our analysis, we estimate that the total value of these six ecosystem services provided by Georgia's 22 million acres of private forests is over $37.6 billion per year. Per-acre values range from $264 to $13,442 depending on the forest characteristics. 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. This represents a lower bound of the public value of private forests for several reasons. The value of some ecosystem services, such as erosion control and ground water recharge could not be explicitly included in our final estimates because there was not enough information available to estimate their value or because the benefits occur on a relatively small scale and could not be incorporated at the state-level. Other technical aspects of the analysis were conducted in a way to insure a conservative estimate.

It is also important to remember that we estimate 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. Two significant components of the total value that are not included are the value of timber and forest products and recreation. Other research has estimated the impacts of these industries on Georgia's economy. Because economic impacts and economic benefits are different things, we cannot add these values together. Economic impacts consider the revenue generated from market activity and trace this revenue through the economy. Economic benefits are the difference between what consumers would be willing to pay for something and what they have to pay. However, when considered together, this body of research provides an overall view of the importance of forestland to the people of Georgia.

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Part 1: Overview

Project Motivation

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 report 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 Table 2. 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.

Defining and measuring economic value

Now that we have defined ecosystem services, we turn to the concept of economic value. Economic value is a measure of the contribution something makes toward human wellbeing (Brown et al. 2007). This is an instrumental type of value, in that something is value because it is a means to an end, in this case, because it brings utility, or happiness, to someone. Ecologists sometimes consider nature to have intrinsic value, or a value independent of any human preference, or even knowledge (Freeman 2003). In this project, we are only interested in the economic value of ecosystem services, but that is not as limiting as it might seem. Economists acknowledge several components that together comprise the Total Economic Value (TEV) of something.

Table 2. Description of ecosystem services.

Ecosystem Service	General Description	Consideration for our analysis
Timber and forest products provision	Raw materials extracted from forests *Used to produce lumber, engineered wood, fuelwood, landscape products, ornamental products, and edible products (fruits and nuts) (Harper et al. 2009)*	Not considered in our analysis. *The benefits of this service are typically shared between the landowner and the consumer of the product.*
Recreation	Potential place for recreation *Georgia has relatively little public land, so private forests play a large role in providing recreational opportunities (Notman et al. 2006)*	Not considered in our analysis. *The benefits of this service are generally enjoyed by the recreational user and require access to the land.*
Gas and climate regulation	General maintenance of a habitable planet *Regulating CO_2, O_2, O_3 (ozone) and SO_x levels in order to prevent disease and maintain clean, breathable air and a favorable climate (de Groot et al. 2002).*	Partially estimated with value transfer. *Due to limited data, our estimates are dominated by climate regulation and the value of carbon storage. Other particulate regulation is partially considered only for urban forests.*
Water quantity and quality	Capture, storage, and filtration of water *Forests mitigate damage from floods and droughts and naturally filter water which is essential for agricultural, municipal, and industrial uses and serves as an intermediate service for other ecosystem services such as recreation and habitat. (Krieger 2001).*	Partially estimated with value transfer. *Our estimates capture some aspects of flood damage, pollution regulation, water supply for surface water. Due to limited data, some important but localized benefits, such as groundwater recharge in south Georgia, are not included in final estimates.*
Soil formation and stability	Forest vegetation stabilizes soil and prevents erosion. *Helps prevent damaged roads and structures, filled ditches and reservoirs, reduced water quality, and reduced fish populations (Krieger 2001).*	Not included in the final estimates. *These services provide relatively localized benefits and could not be incorporated at the statewide spatial scale considered here.*
Pollination	Provide habitat for important pollinator species *Most plant species, including crops, require pollination. As pollinating species are threatened with habitat loss, often costly artificial pollination is required to maintain healthy systems and crops. (de Groot et al. 2002)*	Partially estimated with value transfer. *Available data is limited and our estimate is likely a lower bound.*
Habitat/refugia	Provide living space to wild plants and animals *Both for resident and migratory, game and non-game species; maintain biologic and genetic diversity that provides natural pest and disease control (de Groot et al. 2002).*	Partially estimated with value transfer. *Our estimates include benefits of threatened and endangered species and overall biodiversity. We do not consider the value of habitat in the maintenance of game species habitat as this is a value to the user.*
Aesthetic, cultural and passive use	Scenic, existence, and/or bequest value *People often value the aesthetic quality of forests scenery and attach value to knowing that forests exist now and will continue to exist in the future (Krieger 2001).*	Estimated from survey data.

There are two main components of TEV: use value and non-use (or passive use) value. Use value captures the benefits received by using the resource either directly or indirectly. Examples of direct use include consumptive uses, like timber harvesting or water withdrawal, and non-consumptive uses like bird watching or boating. Direct use requires direct contact with the resource. Many ecosystem services provide indirect use value as well, which do not require direct contact with the resource. For example water and air quality-related services impact the quality of the ecosystem and thus our quality of life, but we do not have to directly interact with the forest to receive these indirect use benefits.

Economic theory and data show that the Total Economic Value of many environmental goods is greater than their use value. This additional benefit is known as non-use, or passive use, value. For example, a person might value knowing that an endangered species exists, even if it has no use value, meaning the person isn't likely to view or otherwise interact with the species, even indirectly. This type of non-use value is known as existence value because it stems from knowing something exists. Another common source of non-use value is bequest value, or the value of knowing a resource will continue to exist for future generations.

We are interested in estimating the indirect use value and non-use value components of the Total Economic Value of ecosystem services from Georgia's private forests. There are several methods used to estimate economic value. These methods differ in terms of the data used, the components of TEV that are considered, whose values are included, and the value metric estimated. Economic theory says that the value of a good to an individual is the difference between what the person would be willing to pay to have the good, and the cost of producing that good. This is also called the total surplus. Unfortunately, total surplus is difficult to measure because we rarely observe someone's willingness to pay (WTP) for something, only what they have to pay. For many ecosystem services, they don't have to pay anything. But just because something is free, does not mean it has zero value. Because of the difficulty with measuring WTP, some valuation methods estimate other related concepts, such as what is actually paid, which is considered a lower bound estimate on true WTP. A more complete discussion of economic value and valuation measures can be found in Brown et al. (2007), Champ et al. (2003), Fisher and Turner (2008) and other sources. We describe these aspects of six general approaches in Table 3.

Table 3. Description of valuation approaches.

Market valuation

- Estimates based on market exchange of the ecosystem good
- *Example:* Observing price fluctuations and demand and supply of timber traded at market values to estimate the demand and willingness to pay (WTP) for timber
- *Data required:* Observations of individual and firm decisions in markets for goods or services
- *Component of value:* Use value only
- *Individuals considered:* Market participants only
- *Value metric:* Can be used to measure WTP with enough data, but typically uses price as a marginal value, which is an underestimate of total WTP
- *Other comments:* Most ecosystem services aren't traded in markets, so this approach can't be used.

Production function

- The value of a non-market resource is estimated based on its contribution as an input to the production of a market good.
- *Example:* Estimating the value of irrigation water as an input for crop production, even if the farmer does not pay a market price for the water.
- *Data requirements:* Data on input and production decisions, market data for the output
- *Component of value:* Indirect use only
- *Individual considered:* Producer
- *Value metric:* Producer's surplus, which is an underestimate of willingness to pay (WTP)
- *Other comments:* Requires the output good to be competitively priced. This approach is often used to value ecosystem goods, but not ecosystem services.

Replacement Cost

- Considers the cost of replacing the ecosystem service with a substitute
- *Example:* Estimating the water filtration services of a wetland by estimating the cost of building a waste water treatment facility to replace these services.
- *Data requirements:* Costs, no observation of decision making required
- *Components of value:* Use value only
- *Individual considered:* Users
- *Value metric:* This is a measure of cost, not value
- *Other comments:* This is a frequent approach for ecosystem service valuation, even thought it is not a measure of true economic value.

Revealed Preference

- Considers individuals' decisions in related markets to infer the value of a non-market good.
- *Example:* There are three primary revealed preference methods
  - **Hedonic Property**: Differences in housing values are used to infer the value of a non-market good. For example, housing prices bordering urban forests may be higher reflecting the buyer's WTP for scenic views.
  - **Travel Cost**: Decisions about where to recreate are used to infer the value of a non-market good. For example, an angler willing to travel further to get to an area with better water quality (and better fishing), is revealing a higher WTP for improved water quality.
  - **Defensive Behavior**: Individuals' actions to avoid damage are used to infer the value of a non-market good. For example, purchasing bottled water to avoid perceived health damages from poor quality drinking water reveals a positive WTP for improved drinking water.
  - **Damage Cost**: Individuals' WTP to avoid damage from pollution or floods must be higher than the cost of dealing with these damages. For example, WTP to for flood protection is at least as high as the direct and indirect cost of repairing flood damage.
- *Data requirements:* Observations of individual decisions (e.g., housing sales, recreation decisions, defensive behavior, damages, etc)
- *Components of value:* Use value only
- *Individual considered:* Depend on the method. The Hedonic Property Method only captures the benefits to homeowners, the Travel Cost Method only captures the benefits to recreational users, etc.
- *Value metric:* Damage Cost Method measures cost, not WTP; The others measure WTP
- *Other comments:* Data requirements are often overwhelming and only a subset of the population is considered.

Stated Preference

- Ask people carefully designed questions to get them to state their willingness to pay (WTP) for a change in environmental quality
- *Example:* A mail survey asking residents how they would vote in a hypothetical referendum that would increase property taxes to provide improved water quality in their area
- *Data requirements:* Survey data
- *Components of value:* Use and non-use value
- *Individual considered:* Depends on the survey sample
- *Value metric:* WTP
- *Other comments:* This is the only approach that can capture non-use values, but these estimates are sensitive to the survey instrument and the population surveyed.

Benefits Transfer (or Value Transfer)

- Adapt value estimates from previous studies to a different context.
- *Example:* Using the results of previous replacement cost, production function, revealed preference, and stated preference studies to estimate the ecosystem service value of Georgia's forests.
- *Data requirements:* Estimates of non-market values from previous studies
- *Components of value:* Depends on the previous studies considered
- *Individual considered:* Depends on the previous studies considered
- *Value metric:* Depends on the previous studies considered
- *Other comments:* There are several approaches to benefit transfer requiring varying levels of adjustment to the transferred values. Benefits transfer is considered a second best option, as error is introduced in the transfer, but it is commonly used due to significant time and cost savings. The results are limited by the availability and applicability of previous studies.

Overview of project 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;

4. Calculate the total ecosystem service value.

These steps are briefly described here, while detailed methods and results for Steps 2, 3, and 4 are found in the next three parts of this report.

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.

Part 2: 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.

Forest Type

Forest Type refers to the dominant ecology of a parcel. Using 2005 Georgia Land Use Trends data, we identified four categories of **Forest Type: Deciduous, Evergreen, Mixed, and Forested Wetland.** Forest Type could affect the quantity and quality of ecosystem services provided, particularly those related to gas and climate regulation, water quality and quantity, recreation, and scenic beauty. Table 4 shows the relative abundance of each forest type in the state. A map of the forest types is shown in Figure 1. Distribution of Forest Type in Georgia.

Table 4. Private forest area by Forest Type.

Forest Type	Acres	Percent of all private forests
Deciduous	5,457,653	25%
Evergreen	11,929,870	54%
Mixed	1,124,921	5%
Forested Wetlands	3,592,174	16%
Total	22,104,618	100%

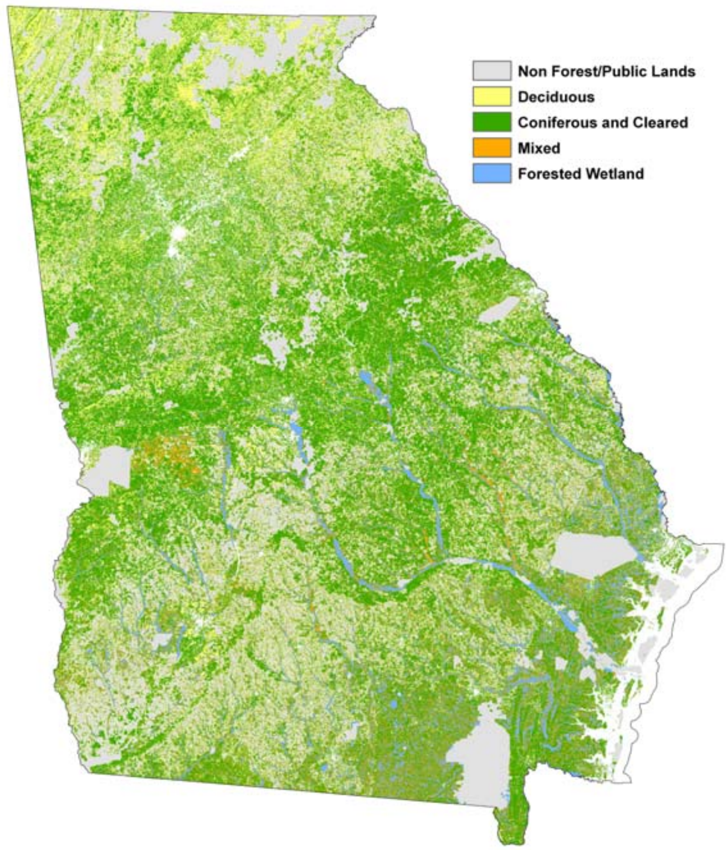

Figure 1. Distribution of Forest Type in Georgia.

Riparian Status

Forests have different impacts on water quantity and quality depending on their position within a watershed. Using DLG Hydrography data, we identified two categories of **Riparian Status: Riparian and Not Riparian**. Riparian includes forests within a 30 m buffer of open and moving water. Note that some areas of south Georgia are particularly important areas of groundwater recharge affecting water supply in Georgia and other states. Due to data limitations this is not considered in our current statewide analysis but should be considered on a localized basis.

Table 5. Private forest area by Riparian Status.

Riparian	Acres	Percent of all private forests
Riparian	3,652,037	17%
Non-riparian	18,452,582	83%
Total	22,104,618	100%

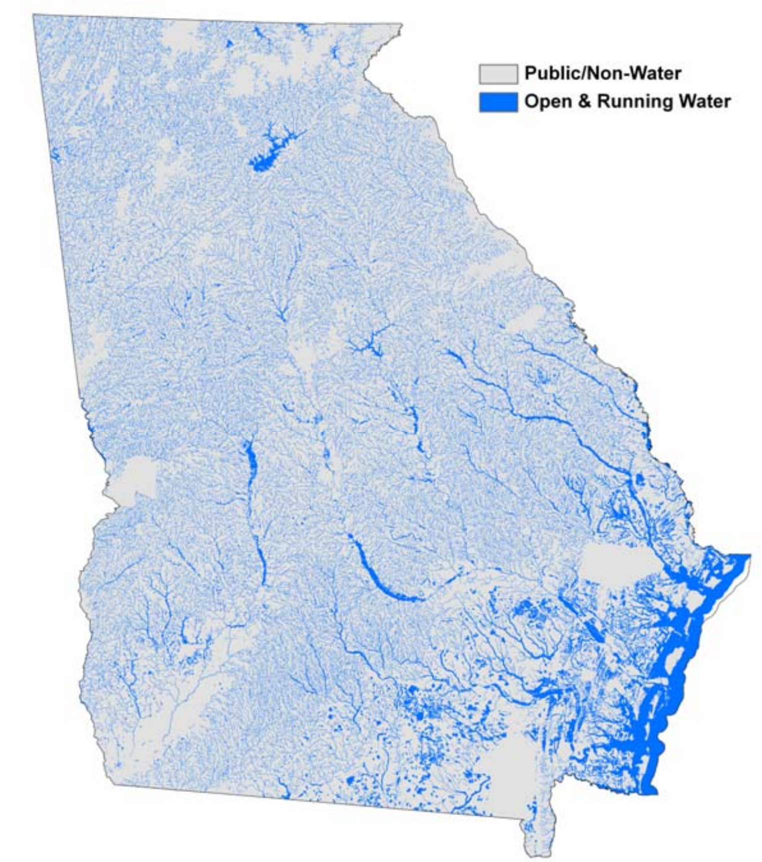

Figure 2. Distribution of Riparian Forests in Georgia.

Rare Species Abundance

Rare Species Abundance refers to the importance of a particular parcel in providing habitat for key species. We used Rare Species Records to identify three categories of **Rare Species Abundance: Low, Medium, and High**, based on the number of rare, threatened, and endangered species (plant and animal) found in an area. Low includes areas with 0 - 5 species (none to few), Medium includes areas with 6 – 11 species (some), and High includes areas with more than 11 species (many). Rare Species Abundance is expected to affect the quantity and quality of wildlife habitat ecosystem services provided by a parcel, thus affecting its per-acre value.

We make three important notes regarding our representation of this forest attribute. First, the data used considers only species of particular conservation concern because they are rare, threatened, or endangered. Species that have cultural, recreational, or other values to human populations, but are not threatened or endangered, are not considered in these counts. Second, of all the data used, Rare Species Records use the coarsest spatial resolution, meaning that data is aggregated over larger areas. Finally, the cutoff points separating the three categories were conservatively selected by the research team. Because areas with higher Rare Species Abundance generate higher per-acre ecosystem service values, the stricter the definition of High Rare Species Abundance, the more confident we can be that our final estimates are a lower-bound on the true estimates. We were aiming for most of the private forestland to be included in the Low category, with roughly 30% in the Middle and only the top 10% in High. The discrete nature of the species count data did not allow these exact proportions, though as Table 6 shows, the final classification is very close to our original goal. Figure 3 shows the location of these categories across the state.

Table 6. Private forest area by Rare Species Abundance.

Wildlife Abundance	Number of Threatened and Endangered Species	Acres	Percent of all private forests
Low	0 – 5	14,173,252	64%
Middle	6 – 11	6,367,531	29%
High	More than 11	1,563,835	7%
Total		22,104,618	100%

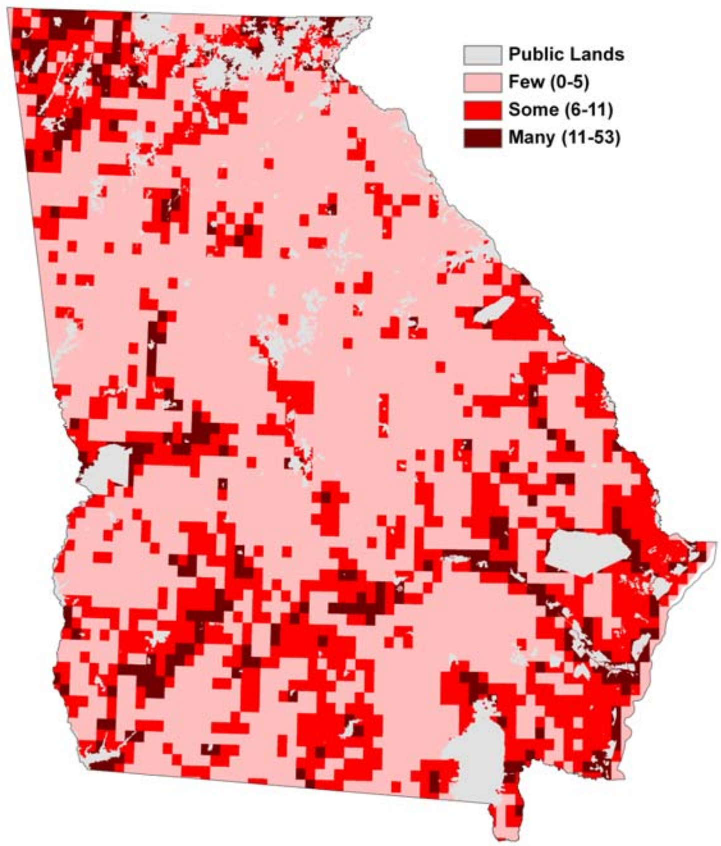

Figure 3. Distribution of Rare Species Abundance in Georgia.

Scenic Visibility

While the public does not necessarily have access to private forests for recreation, some forestland is more visible than others. Scenic visibility is expected to affect the quantity and quality of ecosystem services related to aesthetic value. For our study area, the most obvious predictor of visibility is proximity to major roads. Using data from the Georgia Department of Transportation, we identified two categories of **Scenic Visibility: Roadside and Not Roadside**. Roadside land includes land within a 30 m buffer of Interstates, ramps, State, and County Roads. This is a conservative classification, as it is likely that at least some forests greater than 30 m from the highway is visible to the public and might affect aesthetic values.

Table 7. Private forest area by Scenic Visibility.

Scenic Visibility	Acres	Percent of all private forests
Roadside	1,257,343	6%
Not roadside	20,847,275	94%
Total	22,104,618	100%

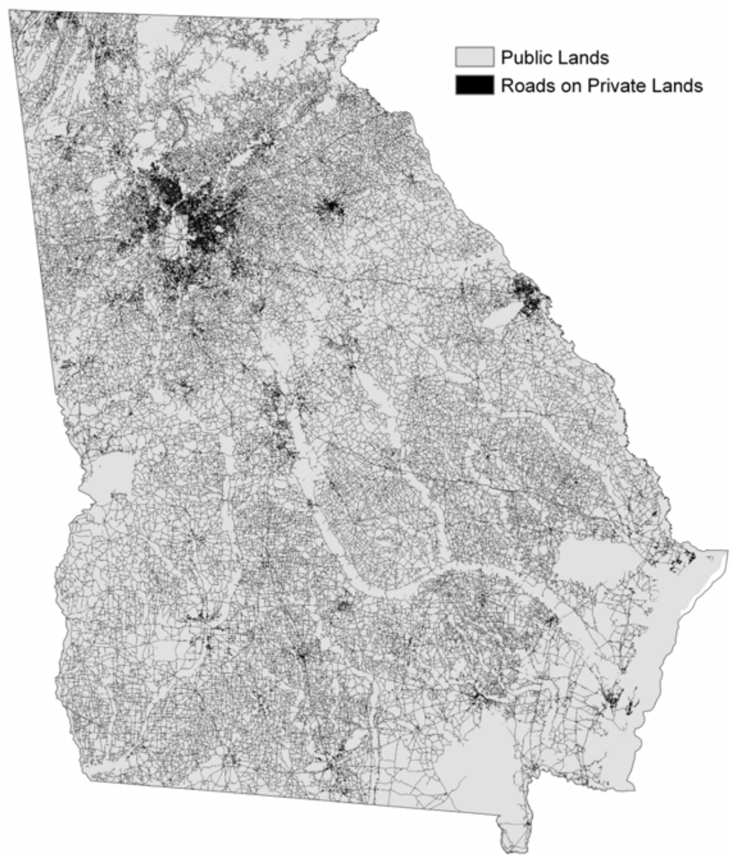

Figure 4. Distribution of roadside forests in Georgia.

Public Land Buffer

It is well documented that the market value of private land is higher for land adjacent to public protected areas such as National Forests, State Parks, and other areas. This price premium is due to the fact that private landowners enjoy private benefits for being adjacent to protected areas. While this is one component of the value of ecosystem services, it is not one that is relevant to our current research because it is a private good. However, it is possible that private land surrounding public land provides some value beyond that captured by the private market. For example, the buffer zone might be more visible to the public if they are accessing the public land for recreation. Also, the buffer zone might protect the public land from encroachment or development pressure, thus affecting the quality or quantity of wildlife or water related ecosystem services. In this way, private land that abuts public land provides an important buffer and might generate greater quantity and/or quality of ecosystem services than other types of private forest land. For that reason, we identify two categories of **Public Land Buffer: Public**

Buffer and Not Public Buffer. The Public Buffer includes private forestland that is within a 90 m buffer of public land.

Table 8. Private forest area by Public Land Buffer.

Public Land Buffer	Acres	Percent of all private forests
Public land buffer	248,687	1%
Not public land buffer	21,855,932	99%
Total	22,104,618	100%

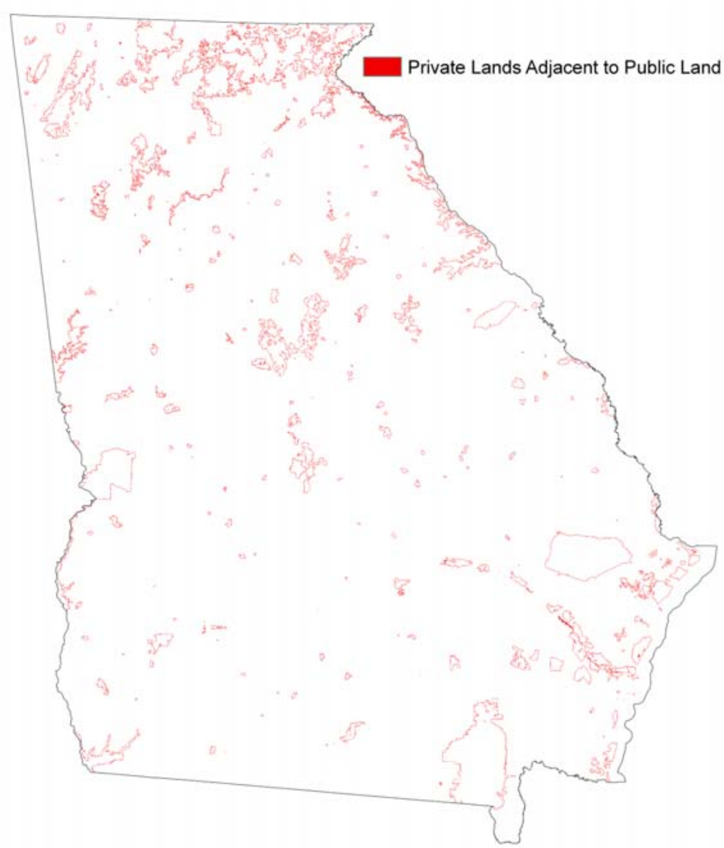

Figure 5. Distribution of forests buffering private land in Georgia.

Development Status

Development Status refers to housing density of an area. While the five forest characteristics already described (Forest Type, Riparian Status, Rare Species Abundance, Scenic Visibility, and Public Buffer) are expected to primarily affect the quantity (or quality) of ecosystem services provided by a representative acre of forest, Development Status affects the "price" component of our value estimates. We suggest three ways in which housing density might affect per-acre values of ecosystem services. First, the benefits of many forest ecosystem services, including pollution control, aesthetics, and non-use value are often estimated as a per-person value and then aggregated to the population receiving these benefits, often the "nearby" population. The more people living nearby, the greater the aggregate benefit to society. Second, basic economic theory suggests that the marginal value of a resource increases as the quantity of resource available decreases. Often called the "scarcity effect" in some of the value transfer literature, this implies that forests in urban areas, where forest are more scarce, provide greater value per acre than in rural areas where forested areas are relatively more common. Third, people living in rural areas might have very different tastes and preference than people living in urban areas. To address these issues, we use data from Wildlands-Urban Interface and Census tracts to identify three categories of **Development Status: Urban, Suburban, and Rural**.

Table 9. Private forest area by Development Status.

Development status	Housing density	Acres	Percent of all private forests
Urban	More than 120 units/km^2	355,571	2%
Suburban	25 – 120 units/km^2	1,352,967	6%
Rural	Less than 25 units/km^2	20,396,080	92%
Total		22,104,618	100%

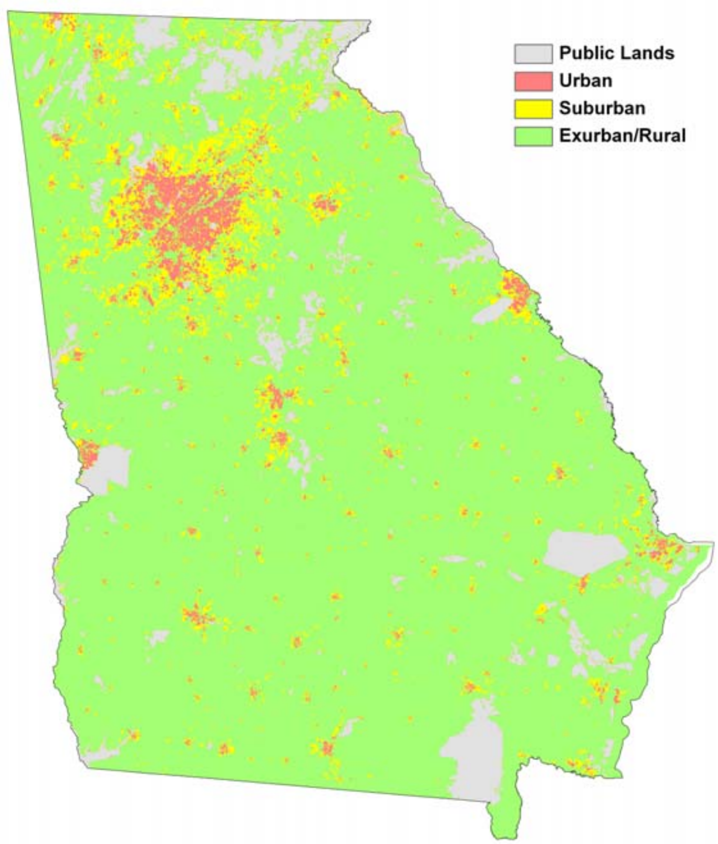

Figure 6. Distribution of Development Status in Georgia.

Geographic Region

In addition to Development Status, we considered Geographic Region as one characteristic of the social aspects of forest ecosystems. We divided the state into three **Geographic Regions: North Georgia, Middle Georgia, and South Georgia**, based on counties. These regions are based on an aggregation of the Survey Units considered by the Forest Inventory Analysis (Harper et al. 2009). Table 10 shows the FIA survey units and counties that correspond to each of our three regions. Differences in attitudes and preferences of the population across regions could affect the per-acre value of ecosystem services, particularly scenic and non-use values.

Table 10. Counties by Geographic Region.

Region	Corresponding FIA Unit	Counties
North Georgia	North and North Central Survey Units	Banks, Barrow, Bartow, Carroll, Catoosa, Chattooga, Cherokee, Clarke, Clayton, Cobb, Coweta, Dade, Dawson, DeKalb, Douglas, Elbert, Fannin, Fayette, Floyd, Forsyth, Franklin, Fulton, Gilmer, Gordon, Gwinnett, Habersham, Hall, Haralson, Hart, Heard, Henry, Jackson, Lumpkin, Madison, Meriwether, Murray, Newton, Oconee, Oglethorpe, Paulding, Pickens, Polk, Rabun, Rockdale, Spalding, Stephens, Towns, Troup, Union, Walker, Walton, White, Whitfield
Middle Georgia	Central Survey Unit	Baldwin, Bibb, Bleckley, Burke, Butts, Calhoun, Chattahoochee, Clay, Columbia, Crawford, Dougherty, Glascock, Greene, Hancock, Harris, Houston, Jasper, Jefferson, Jones, Lamar, Lee, Lincoln, Macon, Marion, McDuffie, Monroe, Morgan, Muscogee, Peach, Pike, Pulaski, Putnam, Quitman, Randolph, Richmond, Schley, Stewart, Sumter, Talbot, Taliaferro, Taylor, Terrell, Twiggs, Upson, Warren, Washington, Webster, Wilkes, Wilkinson
South Georgia	Southwest and Southeast Survey Units	Appling, Atkinson, Bacon, Baker, Ben Hill, Berrien, Brantley, Brooks, Bryan, Bulloch, Camden, Candler, Charlton, Chatham, Clinch, Coffee, Colquitt, Cook, Crisp, Decatur, Dodge, Dooly, Early, Echols, Effingham, Emanuel, Evans, Glynn, Grady, Irwin, Jeff Davis, Jenkins, Johnson, Lanier, Laurens, Liberty, Long, Lowndes, McIntosh, Miller, Mitchell, Montgomery, Pierce, Screven, Seminole, Tattnall, Telfair, Thomas, Tift, Toombs, Treutlen, Turner, Ware, Wayne, Wheeler, Wilcox, Worth

Table 11. Private forest area by Geographic Region.

Geographic Region	Population (2009 US Census)	Acres	Percent of all private forests
North Georgia	6,696,788 (68%)	5,793,381	26%
Middle Georgia	1,556,849 (16%)	6,826,896	31%
South Georgia	1,575,574 (16%)	9,484,341	43%
Total	9,685,744	22,104,618	100%

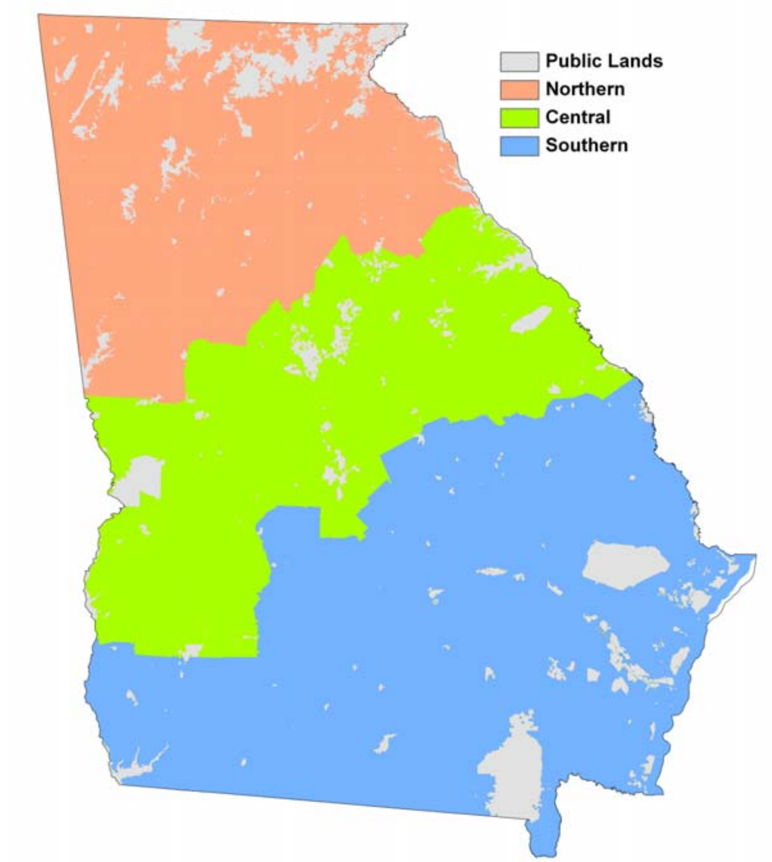

Figure 7. Geographic Regions.

Summary of Landscape Classification

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 12 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 12. 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

Part 3: 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 13 summarizes these values. Appendix A provides a list of all studies used in our value transfer analysis. The remainder of Part 3 provides details of this analysis.

Table 13. 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: This estimate is based on a single study from Sweden.	$184 for non-wetland forests $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	Will come from survey data

Gas and climate regulation

Liu et al. (2010) report per-acre values of $60/year for forest areas and $336/year for urban greenspace (both in 2004 US$). The value for forests is based on 31 point estimates from 14 different published papers. Most of these sources use marginal product estimation, estimating the value of carbon stored as the net present value of avoided damage and other social costs in the future. These estimates are highly sensitive to the discounting model applied to future social costs (Atkinson and Gundimeda 2006). Our review of additional recent literature in this area found a wide range of estimates of the value of carbon stored, typically presented as a value per metric ton of carbon ($/tC). In their discussion of this previous work, Atkinson and Gundimeda (2006) suggest that estimates based on "first-generation" climate damage models (such as Fankhauser 1994) are often over-estimates. Atkinson and Gundimeda conclude that a value of $21/tC is a reasonable estimate of the social cost of carbon, and consider a range from $5/tC to $42/tC to be reasonable bounds on the possible range (all adjusted to 2009 US$).

The 2008 Georgia Forest Inventory and Analysis (USDA FS 2008) estimates Georgia's private forest land contains 426,496,939 tC, or approximately 19 tC/acre. Applying Atkinson and Gundimeda's estimated value of $21/tC, we estimate the value of carbon stored in Georgia's private forests is $404/acre (2009 US$), or $28/acre/year assuming a 7% discount rate. We apply this value to all non-urban forests.

An alternative approach to estimating the social value of carbon is to look at the trading price from existing carbon markets. For example, while it was in operation, the Chicago Climate Exchange (CCX) posted a mean price of $2.1 per metric ton of CO_2, with a historic range of $0.05 to $7.4/t$CO_2$. (1 tC ≈ 3.664 t$CO_2$). However, the closure of the CCX and the voluntary nature of all trading on that market limit the reliability of these values as estimates of the true social cost.

While carbon storage dominates the literature in this area, forests provide additional gas and climate benefits beyond carbon storage. This is most often illustrated in the literature on urban green spaces, where these other benefits are relatively more important do to the larger human health issues and relative scarcity of green space. Liu et al. (2010) base their value for urban green space on three estimates from two different studies. Our review of these sources and an additional paper by McPherson et al. (1997), indicate that the Liu et al. estimates are the most reasonable given the available data. Adjusted to 2009$, we apply a value of $381/acre/year to urban forests for gas and climate regulation.

Water regulation and supply

Liu et al. (2010) reports separate values for water regulation, disturbance regulation (i.e., flood control), and water supply. The combined value for water regulation and supply reported in their study is $8,118 for freshwater wetlands, $2,009 for riparian buffer, and $9 for forests (all in 2004 US$). We consider each landcover type in turn.

Wetlands

Liu et al. base their value for wetlands on seven estimates from six separate studies. However, several of those estimates are not applicable to our study. For example, two of the studies consider the water quality benefits to recreation users which is outside the scope of our study. Also, some of the estimates are applicable only to certain types of wetlands. For example, an estimate of the value of flood protection from Thibodeau and Ostro (1981) is based on analysis of damage estimates from urban and suburban areas. We did not find it was reasonable to transfer these values to rural forests where flood damage costs are typically lower due to less built infrastructure. Table 14 summarizes the results of our review, adjusted to 2009 US$. We apply these values to all Rural and non-Rural forested wetlands.

Table 14. Value per acre, per year of wetland forests

Service component	Rural Wetlands	Urban and Suburban Wetlands
Flood Control		$4,717 (1)
Pollution Treatment	$3,479 (1)	$3,479 (1)
Water Supply	$1,157 (2)	
Total	$4,636 (3)	$8,196 (2)

Numbers in parenthesis are the number of estimates our values are based on.

Riparian Buffer

Liu et al. base their estimates for flood protection and water supply from the riparian buffer on 11 estimates from eight separate studies. We found only four of these estimates applicable to our study. Others were either based on travel-cost estimates of recreation users, or specific to a very localized area, such as a specific estuary in California that was not reasonably transferable to all riparian forests in Georgia. The mean value of these four estimates, adjusted to 2009 US$ is $1,728/acre/year. We apply this value to all non-wetland, riparian forests.

Other Forests

Liu et al. report an estimate of water supply value of other forests of $9/acre, however this is based on a travel cost study and not applicable to our current interests. They also report a separate estimate of $6/acre for water regulation from urban green space based on a single study that is applicable to our study. Adjusted to 2009 US$, we apply an estimate of $7/acre for non-wetland, non-riparian urban forests, and $0/acre for non-wetland, non-riparian non-urban forests. We are severely constrained by the available data in this area and consider these estimates to be conservative. Clearly, riparian and wetland forests are likely to have a greater impact on water quantity and quality, we expect that all forest land contributes to these areas in some way. Without additional data, we cannot include them explicitly in our analysis.

Soil formation

Forest vegetation stabilizes soil and prevents erosion. Unfortunately, our review of the peer-reviewed literature provided no estimates of the value of this service that would be transferable to our study. We considered both the summary analyses of Liu et al. (2010), Costanza et al. (1997), and Troy and Wilson (2006), and our search of more recent literature. This doesn't mean the value is zero. Soil erosion fills ditches and reservoirs, damages roads, and threatens water quality and fish habitat. Removing this sediment or otherwise abating the damage can be very expensive. Forestlands prevent society from having to pay these costs. Krieger's (2001) review of this literature indicated the costs of dealing with sedimentation range of values from $1.94/ton of sediment in the Little Tennessee River Basin in the southeastern U.S. to $5.5 million/year in the Willamette Valley of Oregon. However, since these estimates are very site specific we can not reasonably convert them to average $/acre/year values. As such, our estimate of the value/acre of ecosystem services is a lower bound estimate. When considering ecosystem services of smaller scale projects, it is important to consider the impact of forests, particularly riparian forests, on soil formation.

Pollination

Liu et al. (2010) identify one estimate of the pollination value of forests and we were unable to find additional estimates in the more recent literature. This estimate is based on upland forests and so we apply the value, $184/acre/year (2009 US$), only to non-wetland forests.

Habitat/refugia

Liu et al. (2010) report forest habitat/refugia values of $923/acre/year (2004 US$) based on 8 estimates from 5 separate studies. All of these studies were based on CV estimates. Unfortunately, none of the estimates identified by Liu et al. are appropriate for transfer to our study due to differences in the population surveyed (e.g., European populations might have very different preferences for natural resource management) and the ecosystem of interest (e.g., one study looked at an area of mixed grassland, forests, and range, rather than just forestland).

Our broader search of the literature identified three other relevant studies. Two related to biodiversity in the Pacific Northwest (Garber-Yonts et al. 2004; Xu et al. 2003) and one related to red-cockaded woodpecker habitat in Mississippi (Grado et al. 2009). Garber-Yonts et al. and Xu et al. both use stated choice experiments to estimate the value of improved biodiversity levels in the Pacific Northwest. They report their estimates in terms of mean $/household for residents of the region. Xu et al. estimate separate values for urban and rural households. To transfer these values to our study, we first adjust for differences in the size of the forested area (8 – 8.4

million acres in the Pacific Northwest, 22.1 million acres in Georgia) and the population of Georgia (assuming 18% of Georgia population is rural (USDA ERS 2010)). The results of this transfer suggest values of $322 and $123/acre/year from the Xu et al. and Garber-Yonts et al. studies, respectively. The original intent of these two studies was to estimate the value of improved biodiversity. In our current study, we are interested in the stock value of current habitat. To be conservative in this transfer, we apply the full estimated value of $223/acre/year only to forest land identified as Mid and High Rare Species Abundance.

In addition to the two general biodiversity studies, we identified one study specific to an important endangered species found in some portions of Georgia. Grado et al. (2009) estimate the opportunity cost of managing for red-cockaded woodpecker (RCW) habitat on nonindustrial private forests in Mississippi to range from $7 to $42/acre/year depending on the quality of the habitat for the RCW. We apply an average of these values ($28/acre/year) to evergreen forests in Middle and South Georgia, the primary potential habitat of the RCW. A summary of our wildlife/refugia values is given in Table 15. Note that we consider these to be lower bounds on the true estimates as the estimates do not consider all aspects of habitat value. We expect every acre to provide some positive value for this ecosystem service, however we are constrained by the available data and prefer to underestimate the true value than overestimate.

Table 15. Summary of wildlife/refugia values. ($/acre/year 2009 US$)

	Evergreen forests in middle and south GA	Other forest types
Low Rare Species Abundance	28	0
Middle and High Rare Species Abundance	251	223

Aesthetic and non-use value

While there are many estimates of the aesthetic and non-use value of different types of forests, most are estimated in conjunction with the recreation values, which we do not include in our analysis because these are use values which require access to the land. This is outside the scope of our current project. We did find some studies looking specifically at aesthetic values of pine plantations in the southeast (e.g., Gan et al. 2000; Buhyoff et al. 1986; Young and Wesner 2003). These studies primarily rely on interviews and surveys using pictures of different viewsheds and consider the effect of management activities such as thinning or clear cutting on self-reports of aesthetic value and do not generally involve an economic tradeoff. Because our forest type data is aggregated to general forest type (evergreen vs. deciduous), we could not reasonably transfer the results to our study. For this reason, we rely on data from our stated choice to estimate the aesthetic and non-use values. This process is described in Part 4 of this report.

Summary and Discussion of Value Transfer Protocol

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 16 through Table 18 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 16. 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 17. 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 18. 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.

Part 4: Stated Choice

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. An example of a stated choice section of the survey is provided in Appendix B.

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 19 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 19. 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 20 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 20. 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 21 and Table 22 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 21. 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 22. 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 23.

Table 23. 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

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

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 24. 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 24 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 24 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 25 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 25. 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**

Part 5: Final Results and Discussion

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 26 breaks this value down by ecosystem service.

Table 26. 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 27. Impact of Forest Characteristics on Ecosystem Services summarizes our findings on how forest characteristics impact different ecosystem services.

Table 27. 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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Appendix B: Example stated choice questions.

This is the stated choice section from one version of the survey. There were eight versions of the survey, each with four different stated choice questions.

Section C: Tradeoffs Among Forest Benefits

This section will ask you a series of questions to better understand how you would make decisions regarding our forest resources.

The four questions in this section will ask you to compare alternative futures for Georgia's privately owned forests. For these questions, consider the possibility that you are voting in a referendum to create a program in which forest landowners might voluntarily participate. This program would provide financial incentives to forest landowner who manage their forestland in particular ways. This program would affect the acres of forested land in the state and possibly identify certain forest characteristics that would be of public priority. The public priority may be one or more of the following characteristics:

Wildlife:	Prioritize management of forests to provide the greatest impact on wildlife.
Scenic Beauty:	Prioritize management of forests along roads and highways in order to provide the best scenic vistas.
Water:	Prioritize management of forests near rivers, streams, and lakes in order to have the the greatest impact on water quantity and quality downstream.
No public priority:	The program does not identify a specific forest attribute as a public priority

In addition to the effect on the acres and attributes of private forests, the incentive program may impose a cost to your household. This cost would be realized through some combination of higher prices for wood products, water, energy, or other products. Remember, that **this is money that your household would not have available for other purposes**. The cost of each alternative is listed in the alternative description. These questions ask you to compare the program attributes and cost and decide which program you would vote for.

IMPORTANT: PLEASE READ

- While the alternatives we are posing are hypothetical choices, please consider them as if you were actually voting in such a referendum.
- Remember that we are referring only to **privately-owned forests**. The private owners have their own private objectives for managing their land. **The alternatives we are presenting would not take the place of these private objectives.**
- None of the alternatives would increase public access to private forests. **The purpose of our study is to identify the value of private forested land to the public.**
- Remember, there are no "right" answers to these questions; we are interested in what you think.

C1. Suppose Georgia residents were voting on a referendum that would result in one of these two alternative futures for Georgia's private forests. No other alternatives are being voted on, and one of these two alternatives WILL BE adopted. Compare the two alternatives and indicate which alternative you prefer.

Alternative A

Region 1: North Georgia
Acres of forested land: - 2%
Public priority: Scenic Beauty

Region 2: Middle Georgia
Acres of forested land: - 2%
Public priority: Scenic Beauty

Region 3: South Georgia
Acres of forested land: no change
Public priority: Water

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$100 per year**

Which alternative do you prefer?

I prefer....

☐ **Alternative A**

☐ **Alternative B**

Alternative B

Region 1: North Georgia
Acres of forested land: - 2%
No public priority

Region 2: Middle Georgia
Acres of forested land: no change
Public priority: Scenic Beauty

Region 3: South Georgia
Acres of forested land: + 2%
Public priority: Wildlife

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$500 per year**

C2. Suppose Georgia residents were voting on a referendum that would result in one of these two alternative futures for Georgia's private forests. No other alternatives are being voted on, and one of these two alternatives WILL BE adopted. Compare the two alternatives and indicate which alternative you prefer.

Alternative A

Region 1: North Georgia
Acres of forested land: no change
Public priority: Wildlife

Region 2: Middle Georgia
Acres of forested land: + 5%
Public priority: Wildlife

Region 3: South Georgia
Acres of forested land: + 2%
Public priority: Water

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$75 per year**

Which alternative do you prefer?

I prefer....

☐ **Alternative A**

☐ **Alternative B**

Alternative B

Region 1: North Georgia
Acres of forested land: + 2%
No public priority

Region 2: Middle Georgia
Acres of forested land: + 5%
Public priority: Scenic Beauty

Region 3: South Georgia
Acres of forested land: no change
Public priority: Water

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$25 per year**

C3. Suppose Georgia residents were voting on a referendum that would result in one of these two alternative futures for Georgia's private forests. No other alternatives are being voted on, and one of these two alternatives WILL BE adopted. Compare the two alternatives and indicate which alternative you prefer.

Alternative A

Region 1: North Georgia

Acres of forested land: + 5%

No public priority

Region 2: Middle Georgia

Acres of forested land: + 5%

No public priority

Region 3: South Georgia

Acres of forested land: + 2%

Public priority: Wildlife

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$25 per year**

Which alternative do you prefer?

I prefer....

☐ **Alternative A**

☐ **Alternative B**

Alternative B

Region 1: North Georgia

Acres of forested land: + 5%

Public priority: Scenic Beauty

Region 2: Middle Georgia

Acres of forested land: + 2%

No public priority

Region 3: South Georgia

Acres of forested land: no change

Public priority: Water

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$0 per year**

C4. Suppose Georgia residents were voting on a referendum that would result in one of these two alternative futures for Georgia's private forests. No other alternatives are being voted on, and one of these two alternatives WILL BE adopted. Compare the two alternatives and indicate which alternative you prefer.

Alternative A

Region 1: North Georgia
Acres of forested land: + 2%
Public priority: Water

Region 2: Middle Georgia
Acres of forested land: - 2%
Public priority: Water

Region 3: South Georgia
Acres of forested land: no change
Public priority: Wildlife

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$50 per year**

Which alternative do you prefer?

I prefer....

- ☐ **Alternative A**
- ☐ **Alternative B**

Alternative B

Region 1: North Georgia
Acres of forested land: no change
No public priority

Region 2: Middle Georgia
Acres of forested land: - 2%
Public priority: Scenic Beauty

Region 3: South Georgia
Acres of forested land: + 5%
Public priority: Scenic Beauty

Cost to your household
in higher prices for wood products, water, energy, or other utilities: **$0 per year**