# Initial Natural Resource Economics Assessment for Envision Alachua

*Presented to Plum Creek by KKH Consulting and the School of Forest Resources & Conservation at the University of Florida*

KKH CONSULTING

SFRC School of FOREST RESOURCES & CONSERVATION

May 29, 2014

# Initial Natural Resource Economics Assessment for Envision Alachua

**Presented to Plum Creek by KKH Consulting and the School of Forest Resources & Conservation at the University of Florida**

## Table of Contents



## List of Figures



## List of Tables

## Executive Summary

Ecosystem services are those 'components of nature that are directly enjoyed, consumed or used to produce human well-being' (Boyd and Banzhaf, 2007). Private forest lands provide a number of critical ecosystem services, including: timber production, carbon storage, nutrient retention/water quality, wildlife habitat, and recreation. The monetary value of each of these services can be estimated for a particular area of forestland, allowing stakeholders to put these non-market commodities into economic perspective. Recognizing the value of these services in land use planning is important for sustainable growth decisions and the wellbeing of Florida's residents.

Sustainable land use decisions should explicitly incorporate the economic value of ecosystem services.

The Envision Alachua project represents a conservation-focused approach to development. This approach has the potential to safeguard critical forest-related ecosystem services while also attracting much-needed economic development for this region. The purpose of this study is to understand and help communicate the value of these ecosystem services in the context of Envision Alachua, and to better inform decision-makers and concerned citizens about the economic value of these often overlooked, but critical, services. By quantifying the ecosystem services provided by managed forests, this study may also help to counter concerns expressed by local stakeholders regarding forestry's environmental externalities.

This report expresses, in economic terms, the ecosystem services provided to society by the conservation and managed forest land components of Plum Creek's Envision Alachua plan. This study focuses specifically on the economic value provided by the 23,216 acres of land in East Alachua County that Plum Creek proposes to place under new conservation easements. The dollar values generated by this study can be communicated alongside other job creation and economic development projections to provide a more complete picture of Envision Alachua's economic potential.

Envision Alachua conservation lands provide ecosystem services worth tens of millions of dollars.

This initial natural resource economics assessment demonstrates that the new conservation easements included in the Envision Alachua Plan provide tens of millions of dollars of value to the public in the form of forest ecosystem services. In our most conservative ("low") scenario, carbon stocks provided the largest share of the value (40%), followed by timber production (38%) and water quality (22%).

Results of this study should be viewed as a conservative estimate of ecosystem provision and economic values from these conservation lands. These results can be used to inform policymakers, the public, land managers and other stakeholders about the potential value of forest-based ecosystem services in Alachua County.

This work was conducted at the request of Plum Creek by Katherine Henderson of Gainesville-based KKH Consulting and Dr. Damian C. Adams and Dr. Francisco Escobedo of the School of Forest Resources & Conservation at the University of Florida.

## Section 1: Introduction to Envision Alachua

The Envision Alachua Sector Plan (EASP), submitted to Alachua County in December 2013, establishes the proposed land uses for 60,136+ acres of lands located in the eastern portion of Alachua County. During an extensive 2-year visioning process, community representatives articulated a future vision to leverage the opportunities associated with planning for such a large-scale land area while it remained under a single ownership (EASP, p. 4).

76% of the Envision Alachua land is planned for permanent conservation.

One of the key elements of the Envision Alachua plan is large tracts of permanent conservation lands. As detailed in Section IV of the Plum Creek Envision Alachua Sector Plan, Conservation Land Use is assigned to 46,081 acres, or approximately 76% of the 60,136 acre Sector Plan Area (EASP, p. 80).

Plum Creek, in close collaboration with the regional community, identified these conservation lands in locations that would protect valuable natural resources, and particularly those resources that support the long-term economic and environmental objectives of Alachua County. Specifically, conservation lands were identified based upon the following criteria (from EASP, p. 5):

- Contribution to regional landscape linkages within Northern Florida.
- Protection of large wetland strands and major tributary systems and large, forested wetland strands that provide core habitat that supports numerous native game and non-game species.
- Contiguity with existing conservation lands and Plum Creek conservation easements in Alachua County.
- Opportunity to build upon Alachua County's "Emerald Necklace".
- Contribution to the conservation and enhancement of natural resources, community watersheds and natural preserves (Paynes Prairie, Lochloosa Lake, Newnan's Lake Conservation Area, Orange Lake, Phifer Flatwoods, Balu Forest).
- Enhancement of Lochloosa Creek's connected wetland system to promote linkages for habitat and to build upon East Alachua County's conservation framework.
- Integration of green infrastructure, including its roles in stormwater management to minimize flooding and in maintaining connections between natural areas to support wildlife movement, as well as its role as a community amenity and regional recreation destination.

**Figure 1**, below, shows the conservation areas included in the Envision Alachua Sector Plan, along with surrounding conservation areas and the pattern of linkages between these critical areas. Together, these lands comprise a conservation system that will provide long-term ecological and economic benefits to the region.

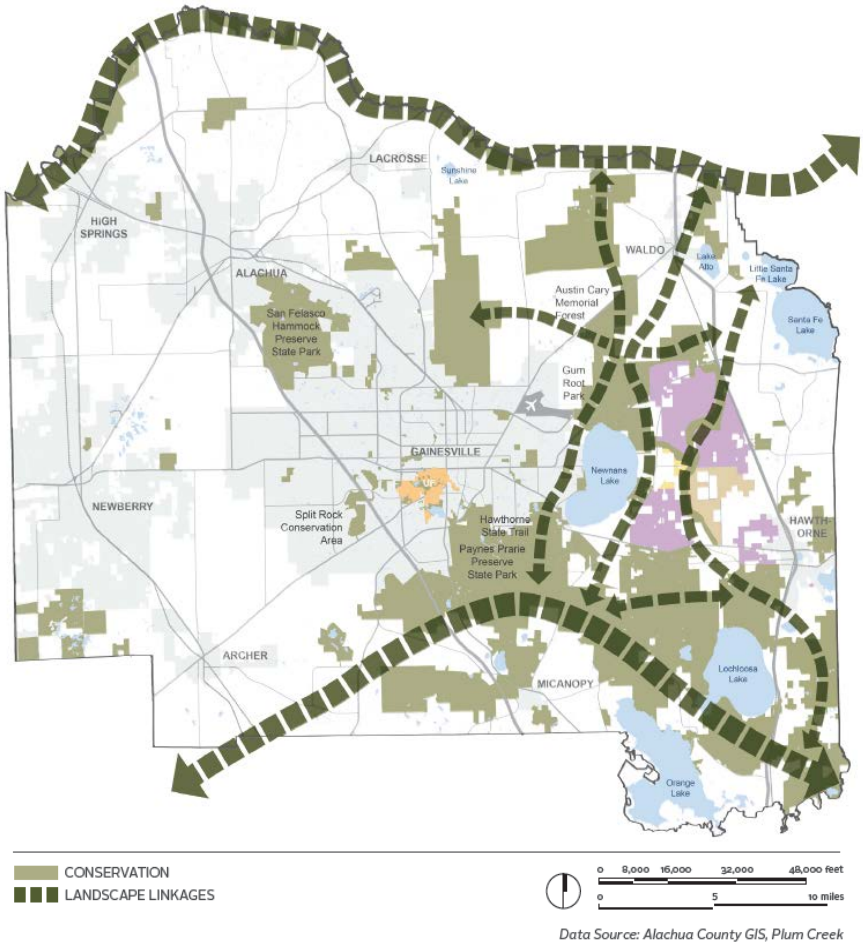


**Figure 1: Conservation Land Use and Landscape Linkages as shown in Envision Alachua Sector Plan (Figure 32)**

## Section 2: Development Allowed by Alachua County Comprehensive Plan

It is critical to note that, in the absence of the Envision Alachua project and the current application to Alachua County, about 37,000 of the ~60,000 acres of Plum Creek's holdings in the County may be developed at a minimum intensity of 1 unit per 5 acres. The pie charts on the following page (Figure 2) depict the contrast between these two futures:

1. Existing condition of ~60,000 Plum Creek acres, according to Alachua County Comprehensive Plan: about 37,000 acres zoned for development at rural/agricultural density.
2. Potential future condition of ~60,000 acres represented by Envision Alachua Sector Plan: majority of acreage (76%) in permanent

<u>Alternate Futures for East Alachua Plum Creek lands</u>

Current Plan:
Majority Zoned for Development

Envision Alachua:
Majority Conserved

conservation via easement; remainder in other land uses, including area of concentrated job creation and economic development (Employment Oriented Mixed Use) which would contain additional open spaces.

Another critical factor for Alachua County stakeholders to consider is the current state of working forests in the area. Landowners such as Plum Creek have harvested timber from southern forests for more than 300 years, and most forests have been harvested multiple times (Wear and Gries, 2011). While working forestland provides significant ecosystem services, as quantified in this report, these conservation areas do not represent "virgin" forestland or natural forest regrowth, and should not be valued or referenced as such.

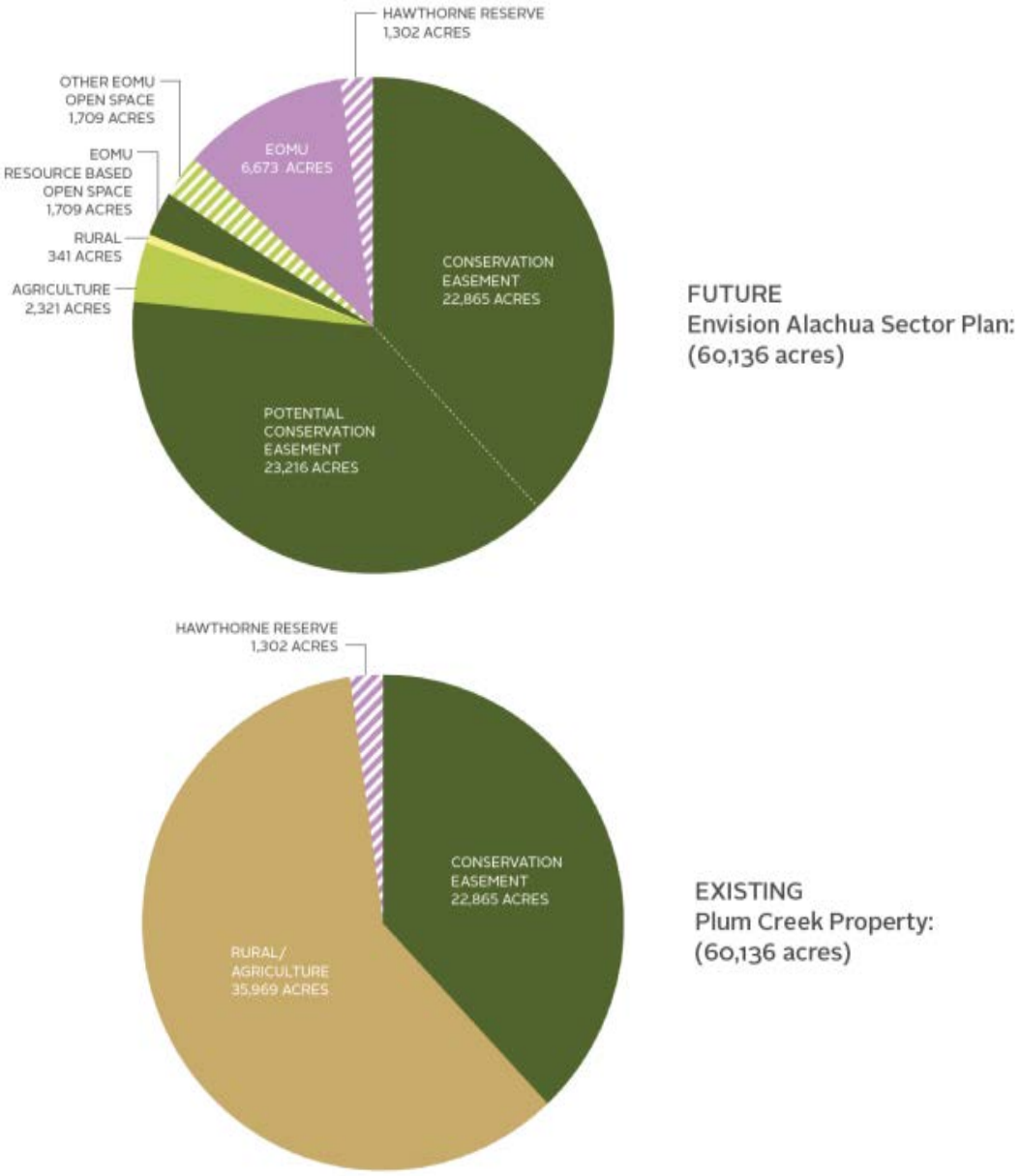


**Figure 2: Long Term Master Plan Framework Land Uses, as presented in the Envision Alachua Sector Plan (Figure 31)**

In summary, these two points should be of central importance in any discussion regarding future land uses on Plum Creek land in Alachua County:

1. In the absence of the Envision Alachua project, MORE acres of land may be permanently converted to a developed use.
2. The Plum Creek lands are working forest lands—valuable for timber production, water quantity and quality, and carbon sequestration, among other ecosystem services. These lands should NOT be viewed as virgin forestland, which would have a different set of inherent values.

## Section 3: Forestry, Timber Markets, and the Florida Economy

Forestry is part of a group of industries that generate significant employment and income, producing goods and services that contribute to the economic stability and growth of Florida, the Southern U.S., and the country as a whole. These contributions are an important consideration for both local land use decisions and broader public policy development.

Forestry-related industries contributed more than $6.6 billion and 80,000 jobs to the State of Florida in 2009.

The timber-related sectors of the Southern economy provide over 1 million jobs and more than 50 billion dollars of employee compensation (data as of 2009, per Wear and Gries 2011). In the state of Florida in particular, *Forestry and Forest Products*, including the sectors *Forestry and Timber Tracts* and *Logging* as well as 16 forest product manufacturing sectors, had combined value-added impacts to the state of Florida of $6.56 billion and employment impacts of over 80,000 jobs in 2009 (Hodges et al. 2011).

The South contains the most intensively-managed forests in the United States. Over the last 50 years, timber production in the region more than doubled and the area of planted pine grew from virtually nonexistent to 39 million acres, or about 19 percent of forests (Wear and Gries 2011). Future timber markets could affect the forests of the South in two important ways, as described by Wear and Gries (2011):

1) Strong timber markets encourage retaining forests rather than converting them to other land uses, so high timber prices can help delay or even reverse forest losses in areas where forest management is still feasible.
2) Strong timber markets encourage continued investment in forest management, and could result from the emergence of markets for bioenergy.

## Section 4: Introduction to Forest Ecosystem Services

Ecosystem services are those 'components of nature that are directly enjoyed, consumed or used to produce human well-being' (Boyd and Banzhaf, 2007). While often unrecognized by humans, ecosystem services are a vital component of our world's ecology and economy. 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, in Moore et al. 2011).

Ecosystem services are also becoming an increasingly useful policy tool, providing economic estimates of intangible and difficult-to-measure environmental attributes that provide great benefit to the environment and society as a whole. Researchers (such as the University of Florida authors of this report) can use ecological and economic tools to estimate the amount and monetary value of specific ecosystem services for a particular area of land, allowing stakeholders to put these non-market commodities into economic perspective. Explicitly incorporating the importance, or value, of these services in land use planning is important for sustainable growth decisions and the wellbeing of Florida's residents.

Private forest lands provide a number of critical ecosystem services to society (Stein et al. 2013). The most important from the standpoint of sustainable development are the ability of forests to do the following (Watson 2008):

1. Protect water quality and quantity (including streamflow, source water for community drinking water supplies, and groundwater) by increasing infiltration and reducing runoff.
2. Protect biodiversity by providing habitat and ability for wildlife to travel and migrate.
3. Sequester carbon that moderates atmospheric changes.
4. Provide wood and other products of economic value in the market.
5. Provide an aesthetic element in the landscape with important spiritual and cultural values.

Conserving working forest land is a cost-effective way to protect water quality, habitat and biodiversity, while sequestering carbon and providing both timber products and recreation opportunities.

Forest ecosystem services, as a part of nature's "green infrastructure," are a particularly important part of sustainable community development because of the key roles they play in reducing the need for more costly human-built "gray infrastructure" (Watson 2008). Conserving forests has been found to be a relatively cost-effective approach to protect water quality and reduce water treatment costs (Chichilinsky and Heal 1998; Ernst et al. 2004). In water recharge areas, every 10% increase in forest cover acres was found to reduce water treatment costs by 20% on average (Ernst et al. 2004).

Traditionally, forest landowners have not been paid for providing ecosystem services beyond commodity production (wood products). As a result, many communities, industries, and individuals act as if these services have no value, and mistakenly assume that the ecosystem services provided by working forests will go on without further investment (Mercer et al, 2011). According to the U.S. Forest Service:

*"Lacking a formal market… critical contributions [of working forests] are often overlooked in public, corporate, and individual decision-making…Recognizing forest ecosystems as natural assets with economic and social value can help promote conservation and more responsible decision-making"* (PFT 2014).

Lacking a formal market, the ecosystem contributions of working forests are often overlooked in land use decisions and policies.

## Section 5: Protection of Working Forests

One approach to protect forestland is to place tracts into the public domain as national forests, parks, wildlife refuges, state forests, or other types of protected landscapes. Although state and local public acquisition programs have gained traction nationwide, in the South their success has been limited (Talberth and Yonagjak 2011). Publicly-owned forests in southern states currently comprise just 13 percent of the region's total forest estate, and it is becoming increasingly difficult to add conservation expenses to public budgets (Hanson et al. 2010 in Talberth and Yonagjak 2011; Talberth 2011). As an alternative, many states, counties and municipalities have turned to creating and protecting "working forests" that protect valuable ecosystem services while also providing tax revenues and other important financial benefits (Talberth 2011).

Recognizing the environmental and societal value of private forest land, some governments pay private forest managers directly for the value of the ecosystem services provided to society by their working forest lands (see sidebar). These payments can help correct for the market's failure to account for valuable ecosystem services, providing additional incentive for landowners to maintain their lands in an undeveloped (working forest) use.

**Payments for Forest-Based Ecosystem Services (2007)**

*"Payments for forest-based ecosystem services to US landowners…totaled $1.9 billion in 2007, with private sources accounting for $1.5 billion (80%) and government agencies providing $366 million (19%). In 2007, sales of forest wetland mitigation credits amounted to $727 million, conservation bank credits $34 million, sales of carbon offsets $1.7 million, conservation easements $315 million, hunting leases and entrance fees $410 million, and wildlife viewing entrance fees $33 million. These figures do not include payments for water services"* (Mercer et al. 2011)

Another form of payment for ecosystem services is a conservation easement, in which a local government or nonprofit purchases certain rights from the private owner—namely, the right to develop that land. In this way, conservation easements maintain private ownership and land management while protecting the land from future development.

Historically, Plum Creek has received an average payment of $434 per acre for conservation easements in Florida.

No payment is sought for the easements included in Envision Alachua.

Over 92,000 acres of Plum Creek working forestlands in Florida are already protected by conservation easements. **Table 1** below provides historical data on Plum Creek conservation easements in Florida, including the acreages and dollar amounts paid by local governments for each. As shown, the average per-acre amount paid to Plum Creek for these conservation easements was $434 per acre. Several of these payments also conferred additional timber management rights on portions of these properties.

Plum Creek already has 22,865 acres in conservation easements in Alachua County, and is proposing to add additional easements covering 23,296 acres of working forest as part of the Envision Alachua project—bringing the total conserved acres under this proposal to 46,081 acres, or approximately 76% of the 60,136 acre Sector Plan Area. Note that the lands offered for conservation easement by Plum Creek as part of the Envision Alachua project are not subject to any payment by the county; these lands and their significant ecosystem services are offered as part of the project's overall public benefit.

**Table 1: Historical Plum Creek Conservation Easement Sales**

| DATE | Grantee | Conservation Easement | Acres | County | Price per Acre | Additional Rights Included in Purchase |
|---|---|---|---|---|---|---|
| 12/1995 | St. Johns River Water Management District | Lochloosa | 16,610 | Alachua | $337 | |
| 12/1999 | SJRWMD, SRWMD & City of Gainesville (GRU) | Murphree Well Field | 7,102 | Alachua | $850 | |
| 12/2000 | Suwannee River Water Management District | Levy County Phase I | 21,300 | Levy | $375 | Hardwood Timber & Management rights on 4,394 acres |
| 3/2002 | Suwannee River Water Management District | Suwannee Swamp LCII** | 12,798 | Levy | $430 | Hardwood Timber & Management rights on 1,402 acres |
| 7/2002 | St. Johns River Water Management District | North Pineland | 6,896 | Volusia | $300 | |
| 7/2002 | St. Johns River Water Management District | Hutton Tract | 4,898 | Volusia | $428 | Hardwood Timber & Management rights on 1,858 acres |
| 8/2002 | Suwannee River Water Management District | Oak Hammock LCII | 4,588 | Levy | $655 | Hardwood Timber & Management rights on 474 acres |
| 1/2005 | FLDEP and SJRWMD | Relay | 18,554 | Flagler | $429 | Hardwood Timber & Management rights on 6,684 acres |
| **TOTAL** | | | **92,746** | | **$434** | |

## Section 6: Methods

We utilize a four-step process for estimating the ecosystem service benefits of the conservation easement component of Envision Alachua (adapted from Moore et al. 2011, p. iii). The first three steps listed below are described in more detail below; step four is covered in Section 7: Results.

1. Identify the geographic scope of the study and the ecosystem services of interest.
2. Determine the appropriate ecosystem classification system based on forest characteristics which predict significant differences in the amount and value of ecosystem services.
3. Use the economic benefit transfer method to estimate average per-acre values for each forest ecosystem type and ecosystem service.
4. Calculate the total monetary value of the ecosystem services for the subject property (see Section 7: Results).

# Step 1: Identify Study Scope

## Geographic Scope

The geographic scope of our study is limited to the 23,216 acres of land in East Alachua County that Plum Creek proposes to place under new conservation easements. These lands are shown in **Figure 3**, below. We isolated only those areas that meet all of the following characteristics:

1. Working forest land owned by Plum Creek in Alachua County.
2. Part of the Plum Creek Envision Alachua Sector Plan.
3. Designated as future conservation areas.
4. NOT part of the current Plum Creek conservation easement or other existing Alachua County conservation lands (as shown in Figure 1, above).

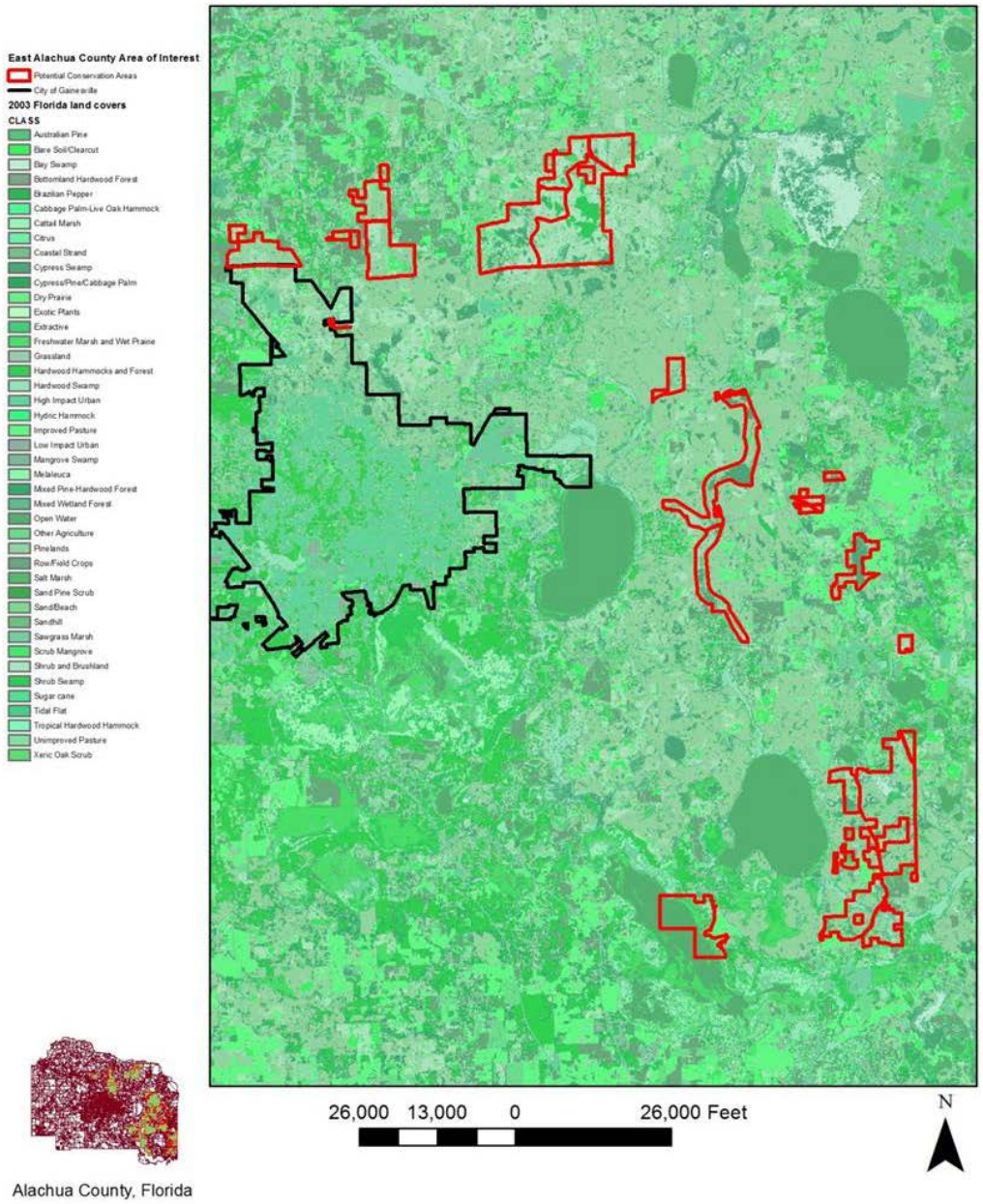


**Figure 3: Study Area—New Conservation Easements within Envision Alachua**

### Select Ecosystem Services

Forests provide numerous ecosystem services, eight of which are summarized in **Table 2** (adapted from Moore et al. 2011). The Plum Creek study described in this report includes the first three of these key ecosystem services, shown in bold. These services were chosen for inclusion based on data availability, published literature, and relevance to the study site. Additional future work may expand the analysis to other ecosystem services.

**Table 2: Forest-Based Ecosystem Services**

| Ecosystem Service | Description | Included in Study |
|---|---|---|
| **Timber and forest products** | **Forests provide raw materials for many uses** | **YES (timber)** |
| **Gas and climate regulation** | **Forests contribute to the general maintenance of a habitable planet by regulating carbon, ozone, and other chemicals in the atmosphere.** | **YES—carbon sequestration (carbon)** |
| **Water quantity and quality** | **Forests capture, store, and filter water mitigating damage from floods, droughts, and pollution.** | **YES—water quality (water)** |
| Recreation | Forests provide a potential place for recreation. | NO |
| Soil formation and stability | Forest vegetation stabilizes soil and prevents erosion. | NO |
| Pollination | Forests provide habitat for important pollinator species who naturally perpetuate plants and crops. | NO |
| Habitat/refugia | Forests provide living space to wild plants and animals. | NO |
| Aesthetic, cultural, passive use | Forests provide scenic value and "existence value." | NO |

## Step 2: Landscape Classification

To assess the value of forest ecosystem services (carbon, timber, and water) conserved under the Plum Creek Envision Alachua project, we applied spatially-explicit maps of proposed Plum Creek conservation areas, and created polygons outlining the relevant areas using a Geographic Information System (GIS; Fig. 3). The GIS polygons were then applied to Florida Fish and Wildlife Conservation Commission (FWC) 2003 land cover data (2004) – generated using Landsat satellite imagery at a resolution of 30 meters (see Kautz et al. 2007) – to classify areas according to 43 land cover and ecosystem types. These classifications were then used to transfer observations on above and belowground carbon stocks and sequestration (Escobedo et al. 2010, Choi and Wang 2004) and timber production (CRSC 2014; Harris et al. 2013).

Land cover categories, or ecosystem types, were then collapsed into seven broader categories (mixed forest, pineland, forest wetland, wetland, water, agriculture/pasture, and urban) to facilitate communication of results by generalized land cover classes. **Table 3**, below, shows the acres of each land cover type found in the study area.

**Table 3: Land Cover Categories in Envision Alachua Study Site**

| East Alachua County generalized land cover classes | 2003 Florida LandCover (FWC 2004) | Timber Mart – South categories (Harris et al. 2013) | Gainesville / Northwest Florida land covers** (Escobedo et al. 2010, Choi and Wang 2004) | Acres | Hectares |
|---|---|---|---|---|---|
| **Mixed Forest** | Mixed Pine-Hardwood | Mixed Forest | Forest | 369.5 | 149.6 |
| | Hardwood Hammock | Hardwood | Vacant | 230.3 | 93.3 |
| **Pineland** | Pinelands | Slash Pine | Forest | 8535.7 | 3456.9 |
| **Wetland** | Freshwater Marsh | n/a | High Marsh | 462.8 | 187.4 |
| | Sawgrass Marsh | | High Marsh | 99.8 | 40.4 |
| | Cattail Marsh | | High Marsh | 122.9 | 49.8 |
| | Shrub Swamp | | Utility | 989.0 | 400.6 |
| | Bay Swamp | | Utility | 284.1 | 115.1 |
| **Forest Wetland** | Cypress Swamp | Cypress | Wetland | 2362.8 | 956.9 |
| | Mixed Wetland Forest | Wetland Forest | Wetland | 1721.3 | 697.1 |
| | Hardwood Swamp | Wetland Forest | Wetland | 972.8 | 394.0 |
| **Water** | Open Water | n/a | Water | 970.8 | 393.2 |
| **Agriculture/pasture** | Shrub and Brushland | n/a | Park | 5104.2 | 2067.2 |
| | Bare Soil/Clearcut | | Utility | 739.4 | 299.4 |
| | Improved Pasture | | Utility | 40.5 | 16.4 |
| | Unimproved Pasture | | Utility | 0.4 | 0.2 |
| | Row/Field Crops | | Utility | 25.1 | 10.2 |
| | Other Agriculture | | Utility | 1.1 | 0.5 |
| | Sandhill | | Utility | 29.8 | 12.1 |
| **Urban** | High Impact Urban | n/a | Residential | 65.1 | 26.4 |
| | Low Impact Urban | | Residential | 70.2 | 28.4 |
| | TOTAL | | | 23198 | 9395 |
| | ***Forest TOTAL*** | | | ***14,192*** | ***5,748*** |

** Land cover classes used to obtain timber*
***Land cover classes used to obtain carbon stocks and carbon sequestration, including above and belowground live tree biomass*

## Step 3: Benefit Transfer—Calculate Value of Each Ecosystem Service

In this study we use a well-accepted valuation method (e.g., Johnston et al. 2005, Rosenberger et al. 2000, Walsh et al. 1992, Williamson et al. 2009) known as benefit transfer (BT) to estimate per-acre production and value of key ecosystem services potentially conserved by the Envision Alachua project. The BT method involves calibrating and applying values generated at study sites to other locations known as policy sites (e.g., Boyle et al. 2010, Johnston et al. 2010). BT is preferred when it is not feasible to conduct novel economic valuation exercises at policy sites due to time or other resource limitations.

In our case, the policy sites are the new areas of working forest to be preserved under conservation easement as part of the Envision Alachua project. BT is generally conducted either by transferring unit-value estimates or benefit functions (Boyle et al. 2010, Woodward et al. 2001). Here, we use the unit-value approach to assess carbon and timber, which involves applying static (e.g., per acre) values from representative study sites to our policy sites in East Alachua County. For water quality, we apply a benefit function (Kreye et al. 2013), which was created to estimate the value of forest-based water quality protection in the Lower Suwannee River watershed.

To facilitate our use of BT, we make several key assumptions, which are explained below, for each of the ecosystem services assessed. For example, we assume that unit-transfer values provide consistent estimates of the ecosystem services produced at policy sites, and the unit-value of these services is fixed with respect to quantity of the service and with respect to time. In practical terms, this means, for example, that the per-acre carbon stock and sequestration value of a hardwood hammock is the same whether there are 10 or 10,000 acres of hardwood hammock assessed.

The three sub-sections below describe and explain the methods and rationale used to calculate the total economic value of our three key ecosystem services: carbon, timber and water. Following these narrative descriptions are three summary tables (**Tables 4, 5 and 6**) which provide additional detail on the inputs and calculations we used to estimate value for each ecosystem service.

### Methods: Carbon

Forests play an important role in the global carbon cycle by sequestering and storing carbon dioxide in the form of biomass (US EPA 2005). In a forest, carbon derived from using carbon dioxide during plant photosynthesis is stored in various carbon "pools": standing biomass, dead and fallen material, belowground, and forest products (Johnsen et al. 2001). Valuing carbon as an ecosystem service can help inform both landowners and policy makers of the value of conservation programs and managing forests for multiple uses, including climate regulation (Escobedo et al. 2012).

Terrestrial carbon sequestration is one of the ecosystem services recognized for its economic value in the marketplace. In the U.S., there are carbon markets associated with three regional cap-and-trade programs (Regional Greenhouse Gas Initiative, Western Climate Initiative, and Midwest Regional Greenhouse Gas Accord) in various stages of implementation, and over-the-counter transactions by entities not otherwise required to reduce their carbon emissions (Charnley et al. 2010). Four major carbon registries (California Air Resources Board, American Carbon Registry, Climate Action Reserve, and Voluntary Carbon Standard) facilitate these carbon market transactions. There are also direct contract arrangements, like the agreement between the University of Florida and a local nonprofit (Earth Givers, Inc.) to provide carbon offsets for carbon-neutral football games and graduation ceremonies, which allowed the university to claim to have the first carbon-neutral athletics program in 2009 (University of

Florida 2009). As carbon markets and other incentive mechanisms continue to emerge, it will be useful to have carbon estimates available to support forest management and policy decisions.

In this study, we quantified carbon stocks on the Plum Creek study area lands and compared estimates with other forested areas in Florida for validation. After classifying the Envision Alachua lands according to the FWC 2003 GIS vegetation and land cover types, we applied above and belowground carbon stock and sequestration data from forest monitoring plots in Alachua County (Escobedo et al. 2010) and marsh carbon values from existing literature (Choi and Wang 2004) to specify BT unit-transfer, per-acre values for carbon in the area of interest. These values were then compared to data from 18 plots from the US Forest Service's *Forest Inventory and Analysis Program* for Alachua County to check for consistency (USDA Forest Service 2014).

After excluding non-forested areas, we applied the per-acre carbon estimates by forest land cover type, and applied assumed values for carbon to the number of acres per land cover type to generate values for carbon stock and sequestration by forest category. We used two assumed prices to drive our analysis: (1) $20 per ton, which reflects the expected intermediate term market price for carbon in the US and is consistent with other studies (e.g., Moore et al. 2011); and (2) $137 per ton, which is the official White House estimate of the social costs of carbon (OMB 2013). We then calculated the per-acre present value for carbon stock and sequestration, assuming a 30-year planning horizon, a 3% discount rate, and 1/3 of carbon stock loss avoided by not converting forest land to non-forest uses, which should yield conservative estimates of carbon losses avoided.

As shown in **Table 4**, the per-hectare (≈2.47 acres) carbon present values ranged from $1,020 to $1,361 for $20/ton and $6,917 to $9,224 when avoided carbon losses are worth $137/ton. Across 5,747.8 forested hectares, avoided carbon stock and sequestration losses for the Envision Alachua project are worth $7.29 million for the expected market price of carbon, and $49.4 million for the avoided social costs of carbon.

### Methods: Timber

Timber products are used to meet a wide variety of private and public needs. The benefits of this ecosystem service are widely recognized and more easily valued than other ecosystem services because market prices exist for both timber forest products (Escobedo et al. 2012).

In this study, timber values were derived in a way similar to that used to estimate carbon values. After categorizing Envision Alachua forest lands according to forest categories that align with pulpwood and sawtimber markets in the south (Table 3), we assumed representative forest growing stock levels based on growth and yield models for southern forests (CRSC 2014) and distribution of soft and hardwood species per forest type, and applied 2013 price data by product categories (pulpwood-hardwood, pulpwood-pine, sawtimber-hardwood, and sawtimber-pine) (Harris et al. 2013). For mixed forests, hardwood, slash pine, wetland forest and hardwood swamp, we assumed two market scenarios: A (pulpwood production) and B (65% pulpwood and 35% sawtimber). For cypress, we assumed scenarios A (pulpwood production) and B (50% pulpwood and 50% sawtimber). Scenario A provides a worst case scenario for timber value, and therefore serves as a boundary. For forest wetlands, stumpage prices were unavailable, so we applied values for hardwoods.

We assumed that real prices were static and equal to 2013 observed prices from Timber Mart – South (Harris et al. 2013), and estimated optimal rotations to maximize land expectation value using the Faustmann model (e.g., Chang 1984) for each forest category and scenario. Per-hectare present value

estimates were then applied to each forest category to arrive at present value of the forest estate by forest category (see **Table 5**).

### Methods: Water

Forest ecosystems are thought to be an effective and sustainable means of buffering aquatic ecosystems against nutrient pollution, thereby functioning as a source of clean water supply (Escobedo et al. 2012). To maintain the water-related ecosystem services provided by forest lands, environmental polices often seek to permanently conserve these lands. In the absence of markets for the ecosystem services provided by forested lands, the economic value associated with protecting water quality through the use of forest conservation programs is often measured using contingent valuation survey methods (Escobedo et al. 2012).

Researchers apply the contingent valuation method by administering surveys that elicit the respondent's willingness-to-pay (WTP—see sidebar) for benefits associated with protecting water quality or other ecosystem services that are not fully valued in the marketplace.

Contingent valuation relies on the ability of the general public to do all of the following:

1. Fully consider actual or expected environmental changes;
2. Translate those changes into a feeling of gain or loss with respect to specific environmental goods and services; and
3. Communicate the magnitude of the gain or loss in monetary terms.

**Willingness-To-Pay (WTP)**

"In economics, value is defined in terms of utility, or well-being, for people. Thus, the value of a good or service to an individual is the amount by which the good increases his or her well-being. The economic value of a good or service is measured as the maximum amount an individual is willing to pay to obtain…the good or service….Willingness to pay (WTP) is [therefore] the preferred measure of value" (Escobedo et al, 2012)

The estimated value water quality protection for the Envision Alachua project is derived from a benefit transfer model developed for use in the Lower Suwannee River watershed (Kreye et al. 2013). The model was developed using a meta-analysis approach that econometrically determined the influence of several factors on the per-household willingness-to-pay for water quality protection. These factors included the valuation method employed, household income, region (e.g., southern U.S.), water resource protected (e.g., river), scale of the protection (e.g., single site versus watershed-level), and type of program (e.g., acquisition/easement versus incentive payments). The model performed well, explaining over 88% of the variation in willingness-to-pay.

The model generated per-household willingness-to-pay for forest-based water quality protection after adjusting for conditions at the policy sites in Alachua County. Here, we assume that: the project's objective is general water quality protection (as opposed to protecting a specific river, for example); the scope of the project is a single site; the proposed conservation mechanism is easement; median household income is $43,252; and there are 96,544 households in Alachua County. The model estimated a mean per household annual WTP of $6.20 (95% confidence interval of $5.67, $6.78), or $598,491 per year. Across 5,747.8 hectares, we find that the per-hectare value for water quality protection is $104 per year. In present value terms, when assuming a 30-year planning horizon and a 3% discount rate, each forest hectare is worth $2,102 for water quality protection (see **Table 6**).

**Table 4: Carbon Values for Envision Alachua Study Site**

| | | | | | Social Cost of Carbon ($137) | | |
|---|---|---|---|---|---|---|---|
| **Forest Category** | **Hectares** | **Carbon Stock* Mg/ha** | **Carbon Sequestered* Mg/ha/yr** | **Value Carbon Stock/ha ($)** | **Value Carbon Seq./ha/yr ($)** | **Present Value 30% Stock and Seq./ha ($)** | **Present Value 30% Stock and Seq. ($)** |
| Mixed Pine-Hardwood | 149.6 | 74.7 | 2.3 | 10,127 | 306 | 9,224 | 1,380,155 |
| Hardwood Hammock | 93.3 | 61.4 | 1.6 | 8,324 | 219 | 6,917 | 645,202 |
| Pinelands | 3456.9 | 74.7 | 2.3 | 10,127 | 306 | 9,224 | 31,885,558 |
| Cypress Swamp | 956.9 | 65.5 | 1.8 | 8,880 | 243 | 7,563 | 7,237,466 |
| Mixed Wetland Forest | 697.1 | 65.5 | 1.8 | 8,880 | 243 | 7,563 | 5,272,334 |
| Hardwood Swamp | 394 | 65.5 | 1.8 | 8,880 | 243 | 7,563 | 2,979,693 |
| ***TOTAL*** | ***5747.8*** | | | | | | ***$49,400,413*** |
| | | | | | **Market Price ($20)** | | |
| **Forest Category** | **Hectares** | **Carbon Stock* Mg/ha** | **Carbon Sequestered* Mg/ha/yr** | **Value Carbon Stock/ha ($)** | **Value Carbon Seq./ha/yr ($)** | **Present Value 30% Stock and Seq./ha ($)** | **Present Value 30% Stock and Seq. ($)** |
| Mixed Pine-Hardwood | 149.6 | 74.7 | 2.3 | 1,494 | 45 | 1,361 | 203,607 |
| Hardwood Hammock | 93.3 | 61.4 | 1.6 | 1,228 | 32 | 1,020 | 95,184 |
| Pinelands | 3456.9 | 74.7 | 2.3 | 1,494 | 45 | 1,361 | 4,703,920 |
| Cypress Swamp | 956.9 | 65.5 | 1.8 | 1,310 | 36 | 1,116 | 1,067,708 |
| Mixed Wetland Forest | 697.1 | 65.5 | 1.8 | 1,310 | 36 | 1,116 | 777,803 |
| Hardwood Swamp | 394 | 65.5 | 1.8 | 1,310 | 36 | 1,116 | 439,580 |
| ***TOTAL*** | ***5747.8*** | | | | | | ***$7,287,801*** |

* Data from Escobedo et al. (2010)

**Table 5: Timber Values for Envision Alachua Study Site**

| Forest Category | Growing Stock | Hectares | % Pine | % Hardwood | Scenario A Only Pulpwood Timber Present Value ($/ha) | Scenario A Present Value Forest Estate ($) | Scenario B Pulpwood and Sawtimber Timber Present Value ($/ha) | Scenario B Present Value Forest Estate ($) |
|---|---|---|---|---|---|---|---|---|
| Mixed Forests | 63.2 | 149.6 | 60 | 40 | 718 | 107,430 | 1,133 | 169,539 |
| Hardwood | 63.2 | 93.3 | 0 | 100 | 677 | 63,126 | 1,113 | 103,850 |
| Slash pine | 65.7 | 3456.9 | 100 | 0 | 775 | 2,680,107 | 1,192 | 4,121,010 |
| Cypress swamp | 258.3 | 956.9 | 100 | 0 | 3,048 | 2,916,694 | 5,389 | 5,156,835 |
| Wetland forest | 94.2 | 697.1 | 0 | 100 | 1,008 | 703,002 | 1,659 | 1,156,519 |
| Hardwood swamp | 94.2 | 394 | 0 | 100 | 1,008 | 397,336 | 1,659 | 653,663 |
| ***TOTAL*** | | ***5747.8*** | | | | ***$6,867,695*** | | ***$11,361,415*** |

| Product Category | $/m$^3$* |
|---|---|
| Pulpwood price hardwood | 10.70 |
| Pulpwood price pine | 11.80 |
| Sawtimber price hardwood | 30.40 |
| Sawtimber price pine | 29.90 |

* Price data from Timber Mart – South (Harris et al. 2013)

**Table 6: Water Quality Values for Envision Alachua Study Site**

| Forest Category | Hectares | Present Value Water Quality ($) | Present Value Water Quality – 33% ($) |
|---|---|---|---|
| Mixed Pine-Hardwood | 149.6 | 314,462 | 104,821 |
| Hardwood Hammock | 93.3 | 196,119 | 65,373 |
| Pinelands | 3456.9 | 7,266,479 | 2,422,160 |
| Cypress Swamp | 956.9 | 2,011,425 | 670,475 |
| Mixed Wetland Forest | 697.1 | 1,465,319 | 488,440 |
| Hardwood Swamp | 394 | 828,197 | 276,066 |
| ***TOTAL*** | ***5747.8*** | ***$12,082,001*** | ***$4,027,334*** |

| Policy Site | Benefit | Scope | Program | Annual Household WTP ($) | Confidence Interval (95%) Low | Confidence Interval (95%) High | Households | Total Annual WTP ($) | Land Area (ha) | Value per ha per yr ($) | Present Value per ha ($) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Alachua county | Protect all water resources | Single site | Acquisition/ Easement | 6.20 | 5.67 | 6.78 | 96,544 | 598,491 | 5,748 | 104 | 2102 |

## Section 7: Results and Conclusion—Value of Forest Ecosystem Services on Envision Alachua Conservation Lands

In total, we estimate that forest ecosystem services provided by the new Envision Alachua conservation easements provide an economic value of between $18.2 million and $72.8 million for the three ecosystem services assessed. This is an average value of between $1,281 and $5,133 per acre.

Final results are provided below in **Table 7**. The table shows our "low" and "high" estimates for each of the three ecosystem services included in the study (water, timber and carbon), along with the percent of total value that each ecosystem service represents under the each scenario. Our finding that the Plum Creek forestland provides between $1,281 and $5,133 per acre in ecosystem services is consistent with other studies (Escobedo et al. 2012, Moore et al. 2011). For example, a recent study of forest ecosystem service values in Georgia found that ecosystem services (gas/climate regulation, water, pollination, and wildlife habitat) from a typical forested acre generates $264 to $13,442 of value per year (Moore et al. 2011). A similar study of working forests in Florida found that the typical acre produces $5,030 worth of ecosystem services (timber, carbon, water quality, and wildlife habitat) (Escobedo et al. 2012).

**Table 7: Total Value of Forest Ecosystem Services Preserved with Envision Alachua Plan**

| | Low | High | Low % | High % |
|---|---|---|---|---|
| **Water** | $4,027,334 | $12,082,001 | 22.1% | 16.6% |
| **Timber** | $6,867,695 | $11,361,415 | 37.8% | 15.6% |
| **Carbon** | $7,287,801 | $49,400,413 | 40.1% | 67.8% |
| ***TOTAL*** | ***$18,182,830*** | ***$72,843,830*** | 100% | 100% |
| ***Avg./ha*** | ***$3,163*** | ***$12,673*** | | |
| ***Avg./acre*** | ***$1,281*** | ***$5,133*** | | |

The goal of this study was to provide an economic assessment of three of the ecosystem services (carbon, timber, and water) conserved by the proposed Envision Alachua plan. Other notable ecosystem services were not included in this assessment, but would likely contribute significantly to the estimated value. These include recreation; soil formation and stability/water quality; pollination; wildlife habitat; and aesthetic, cultural and passive use. Given this, the actual value of ecosystem services provided by these lands is likely much higher than reported here. For example, we know that trees are effective at mitigating air pollution in both urban and rural areas, and that avoided adverse

The actual value of ecosystem services provided by these lands is likely much higher than reported here.

health impacts from select pollutants is valuable. For example, a typical forested acre in Jacksonville, Florida had a pollution removal rate of 95 pounds per acre (Nowak et al. 2006), and pollutant removal in rural areas for carbon monoxide and particulate matter less than 10 microns – both of which are effectively mitigated by trees – is $27/ton and $126/ton, respectively, based on national median externality values (Hirabayashi 2014).

We also know that forests, even working forests that are actively managed for timber production, provide significant habitat for wildlife. For example, a recent Florida study found that the value of wildlife habitat for preventing up to a 5% decline in five charismatic species (red cockaded woodpecker, bald eagle, black bear, gopher tortoise and scrub-jay) on working forests primarily located in North and Central Florida was worth $305 per hectare (Escobedo et al. 2012).

This initial natural resource economics assessment demonstrates that the new conservation easements included in the Envision Alachua Plan are likely to provide tens of millions of dollars of value to the public in the form of forest ecosystem services.

The economic value reported here represents a critical piece of the economic and societal value offered by the Envision Alachua plan as a whole. Other components of economic value offered by this project include significant job creation, commercial and industrial development, and associated tax revenue generation. The dollar values generated by this study can be communicated alongside other economic development projections to provide a more complete picture of Envision Alachua's economic potential.

## References

Boyd, J. and Banzhaf, S., 2006. What are ecosystem services? The need for standardized environmental accounting units. *Ecological Economics* 63, 616-626.

Boyle, K.J., Kuminoff, N.V., Parmeter, C.F., Pope, J.C., 2010. The benefit-transfer challenges. *Annual Review of Resource Economics* 2, 161-182.

Carbon Resources Science Center [CRSC], 2014. Growth, Yield and Carbon Balance Models for Southern Pine Stands. Available at http://carboncenter.ifas.ufl.edu/models.shtml. Accessed February 2014.

Chichilinsky, G., Heal, G., 1998. Economic returns from the biosphere. *Nature* 391, 629-630.

Chang, S.J., 1984. Determination of the optimal rotation age: A theoretical analysis. *Forest Ecology and Management* 8, 137-147.

Charnley, S., Diaz, D., Gosnell, H., 2010. Mitigating Climate Change through Small-Scale Forestry in the USA: Opportunities and Challenges. *Small-scale Forestry*, 9:445-462.

Choi, Y., Wang., Y., 2004. Dynamics of carbon sequestration in a coastal wetland using radiocarbon measurements. *Global Biogeochemical Cycles* 18, GB4016.

Ernst, C., Gullick, R., Nixon, K., 2004. Protecting the source: Conserving forests to protect water. *Opflow* 30(5), 1-7.

Escobedo, F., Varela, S., Zhao, M., Wagnes, J.E., Zipperer, W., 2010. Analyzing the efficacy of subtropical urban forests in offsetting carbon emissions from cities. *Environmental Science and Policy* 13, 362-372.

Escobedo, F. J., Abd-Elrahman, A., Adams, D.C., Frank, A., Kil, N., Kreye, M., Kroeger, T., Stein, T., Timilsina, N., 2012. Stewardship Ecosystem Services Project Final Report. School of Forest Resources and Conservation, University of Florida, Gainesville, Florida. Available at: http://www.sfrc.ufl.edu/cfeor/SESS.html. Accessed March 14.

Florida Fish and Wildlife Conservation Commission [FWC], 2003. 2003 Florida Vegetation and Land Cover. Available at http://myfwc.com/research/gis/data-maps/terrestrial/fl-vegetation-land-cover/. Accessed February 2014.

Harris, T., Smith, J., Baldwin, S., 2013. Timber Mart – South 2013. The Frank W. Norris Foundation, University of Georgia. Athens, GA.

Hirabayashi, S., 2014. i-Tree Canopy Air Pollutant Removal and Monetary Value Model Descriptions. The Davey Institute, Syracuse, NY.

Hodges, A., Rahmani, M., Stevens, T., 2011. Economic Contributions of Agriculture, Natural Resources and Related Industries in Florida in 2009. University of Florida-IFAS, EDIS, FE897, Available at: http://edis.ifas.ufl.edu/fe897. Accessed March 2014.

Johnsen, K. H., Wear, D., Oren, R., Teskey, R. O., Sanchez, F., Will, R., et al., 2001. Meeting global policy commitments: Carbon sequestration and southern pine forests. *Journal of Forestry* 99(4), 14-21.

Johnston, R.J., Besedin, E.Y., Iovanna, R., Miller, C.J., Wardwell, R.F., Ranson, M.H., 2005. Systematic variation in willingness to pay for aquatic resource improvements and implications for benefit transfer: A meta-analysis. *Canadian Journal of Agricultural Economics* 53, 221-248.

Johnston, R.J., Rosenberger, R.S., 2010. Methods, trends and controversies in contemporary benefit transfer. *Journal of Economic Surveys* 24, 479-510.

Kautz, R., Stys, B., Kawula, R., 2007. Florida Vegetation 2003 and Land Use Change between 1985-89 and 2003. *Agricultural and Natural Resource Sciences* 70(1), 12-23.

Kreye, M., Escobedo, F.J., Adams, D.C., Stein, T., Borisova, T., 2013. Valuing the Ecosystem Services of Florida's Forest Conservation Programs: The Economic Benefits of Protecting Water Quality. University of Florida-IFAS, EDIS, FOR 309. Available at http://edis.ifas.ufl.edu/fr377. Accessed March 2014.

Mercer, D., Cooley, D., Hamilton, K., 2011. Taking Stock: Payments for Forest Ecosystem Services in the United States. Forest Trends—Ecosystem Marketplace. February.

Moore, R., Williams, T., Rodriguez, E., and Cymmerman, J. H., 2011. Quantifying the value of non-timber ecosystem services from Georgia's private forests. University of Georgia: Athens, GA.

Nowak, D.J., Crane, D.E. and Stevens., J., 2006. Air pollution removal by urban trees and shrubs in the United States. *Urban Forestry and Urban Greening* 4, 115-123.

Office of Management and Budget [OMB] 2013. *Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866.* Interagency Working Group on Social Cost of Carbon, United States Government.

Pacific Forest Trust [PFT], 2014. Forest Products and Ecosystem Services. Available at: https://pacificforest.org/Rewards-Ecosystem-Services.html. Accessed March 2014.

Rosenberger, R.S., Loomis, J.B., 2000, Using meta-analysis for benefit transfer: In-sample convergent validity tests of an outdoor recreation database. *Water Resources Research* 36, 1097-1107.

Stein, T., Kil, N., Frank, A., Adams, A.E., Adams, D.C., Escobedo, F.J., 2013. Public Land Management Agencies' and Nonindustrial Private Forest Landowners' Perceptions towards Ecosystem Services. University of Florida-IFAS, EDIS, FOR 312. Available at: http://edis.ifas.ufl.edu/fr380. Accessed March 2014.

Talberth, J., Yonagjak, L., 2011. Forests at Work: A New Model for Local Land protection. Water Resources Institute Issue Brief 3.

Talberth, J., 2011. "Working Forests": How Land Protection Can Save and Even Make Money. Water Resources Institute blog post. Available at: http://www.wri.org/blog/working-forests-how-land-protection-can-save-and-even-make-money. Accessed March 2014.

University of Florida, 2009. Gators claim title to nation's first carbon neutral athletic season. UF News. Available at: http://news.ufl.edu/2009/09/03/gators-claim-title-to-nation%E2%80%99s-first-carbon-neutral-athletic-season/. Accessed March 2014.

US Department of Agriculture – Forest Service [USDA Forest Service], 2014. COLE 1605(b) Report for Florida. Carbon On Line Estimator Development Group, Durham NH.

US Environmental Protection Agency [US EPA], 2005. *Greenhouse gas mitigation potential in U. S. Forestry and Agriculture*. Washington, DC. EPA 430-R-05-006.

Walsh, R.G., Johnson, D.M., McKean, J.R., 1992. Benefit transfer of outdoor recreation demand studies, 1968–1988. *Water Resources Research* 28, 707-713.

Watson, 2008. Forest Ecosystem Services and Sustainable Community Development. Sustainable Community Development Code, Research Monologue Series: Environmental Health. The Rocky Mountain Land Use Institute. January.

Wear, D., Gries, J., 2011. The Southern Forest Futures Project: Summary Report. U.S. Department of Agriculture, Forest Research Service and Forest Service. DRAFT Report. May.

Williamson, J.M., Thurston, W., M.T., H., 2009. Using benefit transfer to values acid mine drainage remediation in west virginia. In *Environmental Economics for Watershed Restoration*, Herberling, H.W., Schrecongost, M.T., Eds. CRC Press: Boca Raton.

Woodward, R.T., Wui, Y.-S., 2001. The economic value of wetland services: A meta-analysis. *Ecological Economics* 37, 257-270.