FINAL REPORT

STEWARDSHIP ECOSYSTEM SERVICES SURVEY PROJECT

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Table of Contents

INTRODUCTION

Background

The Florida Forest Stewardship Program (FSP) is administered by the Florida Department of Agriculture and Consumer Services, Florida Forest Service and provides technical assistance to non-industrial private forest landowners. As a part of the program, a team of resource professionals from different governmental and educational organizations helps the landowners develop a stewardship plan based on the landowner's management objectives. The plan will include forest stand characteristics, property maps, management recommendations, and a five-year planning cycle. Participants who consistently practice proper management and follow the recommendations within their stewardship plan receive certification (http://www.floridaforestservice.com/forest_management/cfa_steward_index.html). The program is a highly important conservation tool for the state and is the key outreach mechanism between state and private forest partners. The program encourages nonindustrial private forest (NIPF) landowners to voluntarily manage their lands for multiple uses (such as timber, wildlife, soil and water, recreation, aesthetics, and grazing), thus maintaining the ecosystem services derived from these lands.

Florida's NIPF lands provide many ecosystem services to society, so recognizing the values of these services in land-use planning (especially at the county planning level) could be important for the long-term sustainability of Florida's forest lands. Florida currently has approximately 2,000 forest landowners enrolled in the stewardship program. Of these, roughly 14% of the properties have been certified, having completed their management plan practices. With approximately 437,823 acres of properties participating in FSP across the state in 2010 (Tony Grossman, Florida Forest Service, personal communication), it is of vital importance to determine the ecosystem services and economic value these properties provide to the residents of the state.

Ecosystem services have been defined differently by ecologists, economists and land managers, but are usually defined in reference to humans and their well-being. It is this attribute that distinguishes them from *ecosystem functions*, which occur whether or not there are any humans who benefit. Quantifying and assessing ecosystem services allow for a systematic and comprehensive accounting of the environmental benefits people receive from forests (Boyd and Banzhaf 2007; Fisher and Turner 2008). Often definitions of ecosystem services are case-specific and depend on the goals of the analysis. Brown et al. (2007) for example, define ecosystem services as "the specific results of ecosystem functions that either directly sustain or enhance human life." Similarly, Fisher et al. (2009) define ecosystem services as "aspects of ecosystems utilized actively or passively, directly or indirectly to produce human well-being." Boyd and Banzhaf (2007) and Kroeger and Casey (2007) narrow the definition further by arguing that only components of nature that are directly enjoyed, consumed or used to produce human well-being should be counted as final ecosystem services. As such, these last two definitions are the most useful for this study because they are well-suited for measuring and estimating the value of ecosystem services. Throughout the following sections, this study and report define ecosystem services as *the components of forests that are directly enjoyed, consumed, or used to produce specific, measurable human benefits.*

Measuring and assessing these ecosystem services and educating NIPF landowners and policy makers about their benefits will encourage them to consider the benefits of maintaining and conserving their working forests, thus protecting critical natural resources in the state. Information on ecosystem services provided by NIPF should also be useful for educating policy makers and the public on the need for forest conservation programs and reducing forestland conversion and fragmentation during development of land-use planning policies and decisions. To address these needs, this project's goals were to

1. Identify ecosystem services of importance to both private landowners and public land managers;
2. Quantify the ecosystem services of FSP-NIPF lands using existing data, statistical analysis and the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model;
3. Apply economic valuation methods and the InVEST model to estimate the economic value of 5 key ecosystem services (water yield, water quality, carbon stocks, wildlife habitat, and timber); and
4. Synthesize and spatially analyze results at the state, ecosystem/watershed, and property level.

This report includes the following sections: First we summarize the study's research finding and implications for policy makers. Next, the executive summaries for all different studies conducted as part of this project are provided. Finally, detailed reports for the different studies are included in the individual reports section. Reports present a statewide or regional ecosystem service assessment for Florida forests, and some (i.e. carbon, timber, and perception survey) include specific analyses of FSPs and an additional regional case study focused on the Lower Suwanee River watershed. The executive summaries and detailed reports are presented in the following order:

1. *Perceptions of ecosystem services by public land management agencies and non-industrial private forest owners*: Presents results of a survey that was conducted to understand decision-makers' and private landowners' perceptions and preferences for specific ecosystem services.

2. *Water Purification: Nutrient retention*: This section describes InVEST model estimates of water yield and nutrient retention services provided by forests and the associated economic values.

3. *Economic value of water resource protection and forest conservation*: Presents results of an economic analysis, using existing valuation literature, that determined the willingness to pay (WTP) for water and forest conservation programs that protect water quality.

4. *Carbon stocks on forest stewardship properties and adjacent lands*: This section compares carbon stocks on existing Florida forest stewardship properties and adjacent non-forest stewardship lands and their economic value.

5. *Managed Timber Production*: Timber production benefits provided by forest stewardship properties under different timber harvest scenarios are discussed and their economic benefits are compared using the InVEST model.

6. *Wildlife*: Presents an economic analysis of the value of conserving habitat for key threatened or endangered wildlife species on Florida Forest Stewardship Program forests.

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Highlights for Policy Makers

The Florida Forest Stewardship Program (FSP) is a voluntary program that provides technical assistance to Non-Industrial Private Forest (NIPF) landowners and encourages them to manage their forests for multiple uses such as timber production, wildlife habitat, soil conservation, clean water, climate regulation and air quality, enhanced recreation opportunities, aesthetics, and forage for livestock grazing. By participating in the FSP, these forests provide a long-term and consistent supply of ecosystem services in addition to ensuring stable income from timber production.

This Stewardship Ecosystem Services Study (SESS) assessed several key ecosystem services provided by NIPFs enrolled in the FSP, economic values of these services, and attitudes and knowledge of NIPF landowners and land management agency personnel about ecosystem services. The SESS defines ecosystem services as *the components of forests that are directly enjoyed, consumed, or used to produce specific, measurable human benefits* (Boyd and Banzhaf 2007).

For the first part of the SESS, we quantified and assessed the economic values of four ecosystem services provided by Florida's forested lands including nutrient retention/water quality, carbon stocks, timber production, and wildlife conservation. Our estimates are based on the best available data, current models and geospatial tools, and conservative assumptions. The ecosystem services that were quantified and the economic values reported here are only parts of the valuation picture for FSP lands. Results of the study should be viewed as a conservative estimate of ecosystem provision and economic values from these lands, but they can be used to better inform policymakers, the public, and land managers about the potential value of forest-based ecosystem services in Florida and the economic loss associated with urban development or conversion of working forests.

We found that by implementing better forest management practices such as those encouraged by the FSP and avoiding development and forest conversion, loss and degradation of wildlife habitat can be reduced for nearly 50 threatened, endangered or otherwise rare species in Florida. The economic value of the avoided losses in bald eagle, red-cockaded woodpecker, Florida black bear, gopher tortoise, and Florida scrub-jay populations expected to be brought about by forest management objectives encouraged by the FSP is approximately $54 million in present value. Furthermore, for conservation programs such as the FSP that protect water quality, annual household willingness to pay (WTP) in Florida ranged from $17 million to $335 million. This WTP depended on specific program characteristics, and was lower for programs that included land acquisitions and conservation easements than for voluntary programs like the FSP. Other studies in Florida have found similarly high values associated with water- and wildlife-related natural resource use. For example, state residents and visitors spend an estimated $7.8 billion per year statewide on fishing, hunting, and wildlife watching (USFS 2008) and visitors to state parks are estimated to be WTP approximately $89 million per year to control invasive plants that negatively impact ecosystem services (Adams et al. 2011).

Additionally, we assessed the ecosystem services provided by FSP forests relative to other private and public forests by using comparative analyses of inventory data from FSP and non-FSP forests. We found that in northeastern and central Florida, net timber volume was greater on FSP forests than on adjacent non-FSP forests and in northern Florida, average total carbon stocks on FSP forests were greater than in immediately adjacent Non-FSP forests; implying potential economic gains for forest owners enrolled in FSP. Finally, in the Lower Suwanee Watershed, nitrogen retention, necessary for maintaining water quality, was generally higher in sub-watersheds with more FSP forest area, as compared to sub-watersheds with no FSP forests.

Altogether, we estimate that the typical acre of forest land enrolled in the FSP program provides ecosystem services that have a present value of $5,030 per acre (Table 1). Our results are consistent with the findings of a similar study in Georgia, which found that a typical acre of forest land generates ecosystem services (i.e., gas and climate regulation, water regulation/supply, pollination, and habitat/refugia) worth $264 to $13,442 *per year* (Moore et al. 2011). For the 437,800 acres enrolled in FSP during 2010, we estimate that the present value of ecosystem services from these lands is more than $2.07 billion. In relative terms, water provided the largest share of the value (66%), followed by carbon stocks (25%), timber production (7%) and wildlife (2%).

Table 1. Estimated value of ecosystem services from Florida Forest Stewardship Program (FSP) lands[a]

		Average Present Value (2010 $)			
Service	Description	All FSP lands	Per hectare	Per acre	Percent of total
Water purification	Value of maintaining water quality[b]	$1,446,357,500	$8,160	$3,300	66%
Carbon stocks[c]	Value of carbon stocks, assuming $19 per MgC	$558,827,870	$3,150	$1,280	25%
Timber[d]	Value of timber using the InVEST model	$10,100,550	$825	$330	7%
Wildlife (Non-use value)	Value of preventing up to 5% loss in populations of 5 charismatic species	$54,112,000	$305	$120	2%
Total		**$2,069,398,000**	**$12,440**	**$5,030**	**100%**

[a]Baseline is 437,823 acres of FSP lands converted to land uses that reduces these ecosystem service values to zero.

[b]Value shown is based on estimated household Willingness To Pay (WTP) in north Florida, where most FSP lands are located. Assumes a 3% discount rate and 1/3 of the total WTP for water quality protection is allocated to least-cost water quality protection programs like the FSP (Chichilinsky and Heal 1998).

[c]Assumes average per-acre value in northwest Florida and a 3% discount rate, similar to the average $/acre value for the 4 USDA-FS Forest Inventory and Analysis regions.

[d]Total per acre average present value for northeastern Florida.

Results of our survey of landowners and agency personnel show that private landowners already appreciate many ecosystem services provided by their lands, such as recreation/scenery, water quality, and timber. However, a majority of surveyed NIPF landowners are more likely to manage their lands for timber and land managers do not explicitly manage for certain key ecosystem services. Therefore, our findings can be used to develop education programs for landowners and managers to raise their awareness for less recognized ecosystem services and benefits such as carbon markets, recreation and wildlife viewing opportunities, and the production of non-timber forest products.

The SESS also highlighted available tools, approaches, and data that can be used by agencies and organizations in Florida to assess ecosystem services such as accessible USDA Forest Service Forest Inventory and Analysis data and geospatial analysis tools, the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model (http://www.naturalcapitalproject.org/InVEST.html), and econometric analyses of data from existing literature. The information provided from this SESS report can also be used for developing incentive programs and identifying potential revenue sources for forest stewardship and conservation programs such as Payment-for-Ecosystem-Service markets. Results can also be used to gauge the public support for funding programs similar to the FSP. Finally, the study results can assist in selecting the program characteristics that ensure broader landowner participation and higher public support (e.g. programs that rely on an appropriate mix of conservation easements and other policy instruments).

The second part of the SESS, currently underway, will analyze the barriers, supply potential, management indicators, and optimal policy characteristics for sustained provision of ecosystem services from private forest landowners (e.g. carbon, water, recreation). We will also develop extension education materials (e.g. publications, websites, and webinars) for policy makers on how to better use the SESS information about the economic values of ecosystem services and landowners' forest management preferences. Specifically, educational materials will discuss how to promote the concept of ecosystem services and their value, outline methods and tools for quantifying ecosystem services, discuss indicators to evaluate the effectiveness of the FSP, and highlight other ecosystem services of interest to non-industrial private forest landowners. We expect that our results can be used to inform the public, policymakers, and land managers about the benefits of programs such as the FSP that maintain and conserve working forests.

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Key Research Highlights

- The perceptions of public land managers towards the types of ecosystem services and their importance differ widely. The main ecosystem services that were identified as a land management agency's responsibility were: recreation or recreation-related services (e.g., aesthetics and scenery), wildlife habitat, and natural resources conservation.

- Non-industrial private forest (NIPF) landowners ranked "enjoyment of scenery" and "overall environmental quality for recreation opportunities" and "quality of drinking water" as the ecosystem services most important to 75% of respondents. Familiarity of respondents with terms such as "ecosystem services" and "carbon storage" was highly variable.

- The Lower Suwannee River Watershed in Florida exported about 54,000 kg and retained 842,000 kg of nitrogen per year. Nitrogen loading was 2,142,750 kg, 2% was exported to the stream and 39% was retained by the vegetation; the remaining 59% were transported to the stream but were within the critical annual load. Also, approximately 8,000 kg of phosphorus were exported to the stream and 246,760 kgs were retained in the watershed.

- Both the nitrogen retention and export to the stream in the Lower Suwanee were higher in the sub-watersheds with a higher area of Forest Stewardship Properties (compared with the watersheds with no-FSP properties); however, these differences were not statistically significant, and could be due to the low number of watersheds with higher total acreage of FSPs (n=10) compared to the other group (n=35).

- The Public's willingness to pay (WTP) for water resource protection and related forest conservation programs that protect water were assessed using an economic analysis based on 43 published WTP estimates.

- Annual household WTP in Florida ranged from $3.32 to $4.79 for programs that implemented land acquisition or easement type strategies (annual total of 17 million dollars state-wide) and $64.81 to $94.01 for programs that do not disclose how programs will be implemented (annual total of almost $335 million dollars).

- The average total carbon stocks on Forest Stewardship Properties (FSPs) in Northwestern Florida were 166 Mega grams carbon per hectare (Mg C/ha) and ranged from 104 to 266 Mg C/ha). Non-FSP forests immediately adjacent to FSPs had lower average values (138 Mg C/ha; ranged from 32 to 362 Mg C/ha). The economic value of carbon on FSPs ranged from $520 to $10,640 per ha with an average value of $3,154 per ha. Similarly, non-FSP forests adjacent to FSPs ranged from $160 to $14480 with an average value of $2,622 per ha.

- The total carbon stored in the Lower Suwannee watershed was approximately 26 million Mg. Total carbon for sub-watersheds ranged from 182 Mg C/ha to 302 Mg C/ha, with an average of 220 Mg C/ha.

- Based on USDA Forest Service Forest Inventory and Analysis data, net timber volume ranged from 52.6 to 162.4 m^3/ha in analyzed forests and was greater on non-FSPs in Northwestern and Southern Florida but was greater on FSPs in Northeastern and Central Florida.

- Timber analysis using the InVEST model indicates that there were no differences in timber production between FSPs and a non-FSP forests that used typical forest management approaches.

- Forests managed using non-FSP criteria had greater annual timber revenues because of the greater amount of available timber for harvest at a higher price. However, this revenue does not reflect other co-benefits such as soil and water conservation, wildlife habitat and wetland protection, and recreation opportunities that are maintained by avoiding loss or conversion of these forests.

- Economic analyses estimated the value of conserving habitat for red cockaded woodpecker, bald eagle, black bear, gopher tortoise and scrub-jay on Florida FSP forests.

- Mean estimate of total statewide WTP for the FSP's benefits of avoided population losses in bald eagles, red-cockaded woodpeckers and scrub-jay are approximately $54 million; different valuation approaches resulted in combined statewide economic value of avoided losses for 3 key wildlife species that ranged from $5.9 million to $128 million.

- The typical acre of forest land enrolled in the FSP program provides ecosystem services worth $7,035.
- For the 437,800 acres enrolled in FSP during 2010, we estimate that the present value of ecosystem services from these lands is more than $2.07 billion.
- In relative terms, water provided the largest share of ecosystem service value on FSP lands (66%), followed by carbon stocks (25%), timber production (7%), and wildlife (2%).

Executive Summaries

Public and Private Landowner Survey of Ecosystem Services

This study examined public and private land managers' perceptions, knowledge, and attitudes towards ecosystem services. Specifically, it asked their knowledge of the concept, and related concepts, as well as what they consider to be their most important (i.e., highest priority) ecosystem services. Also, specific questions were asked about their management practices and other management aspects associated with their lands. Two questionnaires were distributed to two different populations: public land management decision-makers (i.e., high level administrators) from the local to federal level, and private landowners who participate in forestry education programs (e.g., Florida Forest Stewardship Program).

Results show that public land decision-makers are widely distributed on what ecosystem services they provide to society and what are their priority services. However, recreation consistently received high marks by a majority of participants. When decision-makers were asked to list all the ecosystem services they believe are their agency's responsibility to provide to society, recreation or recreation-related services (e.g., aesthetics and scenery) were listed most often. Also, responses associated with habitat and natural resources conservation were listed as much as recreation-type responses. When given a specific list of ecosystem services to rate and rank, "overall environmental quality for recreation" was the service most often listed as the agency's first priority. In addition, "quality of drinking water" and "flood prevention" were consistently listed in the top five priorities. "Terrestrial carbon storage and sequestration to mitigate global climate change" was absent from the list of agency's top three priorities, but one respondent mentioned it as the agency's fourth-highest priority and four respondents mentioned it as their fifth highest priority.

Survey results for private landowners showed that 84.5% of the respondents listed "enjoyment of scenery" as important and 72.4% rated "overall environmental quality for recreation opportunities" as important. "Quality of drinking water" also received high scores, with 75.0% rating it as important. Other questions showed respondents are highly variable in their degree of familiarity with terms like "ecosystem services" and "carbon storage." For example, participants said they are familiar with terms like "water quality," but are not as familiar with terms like "ecosystem services" and "carbon storage." Most respondents said they used their land for recreation purposes at least several days a month, with day hiking/walking, viewing scenery, and wildlife viewing listed as the most popular activities.

Water Purification: Nutrient Retention

The value of the role of forested ecosystems in the nutrient retention process was analyzed using the Integrated Valuation of Ecosystem Service and Tradeoffs (InVEST) Water Purification: Nutrient Retention model (http://www.naturalcapitalproject.org/InVEST.html). This analysis: (1) identified the nutrient retention (e.g. nitrogen and phosphorus) services provided by ecosystem on the Lower Suwannee River watershed and (2) determined the economic benefit (avoided cost) provided by the ecosystem in terms of nutrient filtration. The Lower Suwannee watershed was selected as the study site due to its hydrological nature and the fact that 15% of all Florida Forest Stewardship program (FSPs) properties are within its boundary. Results also include total water yield, total amount of nutrients retained, and the economic value of water purification presented at the sub-watershed scale. Water yield or precipitation that does not evaporate or transpire from the Lower Suwannee River watershed was 805.5 mm/year (ranging from 657.8 to 955.2 mm/year). Results show that water yield was higher in sub-watersheds without FSP than those with a greater amount of FSPs and the difference was statistically significant. This could be attributed to higher forest cover associated with FSPs. The InVEST model water yield output performance was assessed using measured, 10 year time period, streamflow data from the most downstream point of the Lower Suwannee watershed.

Nutrients loaded in the watershed can take three paths: (1) retained by vegetation, (2) exported to the stream beyond the critical annual load value, and (3) exported to the stream within the critical annual load value. The total amount of nitrogen (N) loaded in the Lower Suwannee watershed was 2,142,747 kg. The annual nitrogen exported to the streams beyond the critical annual load from the uplands was approximately 54,073 kg (2.5% of the total loaded) and the total amount of annual N retained was 842,034 kg (39%). The remaining 58.5% was exported to the stream but was within the critical annual load. Approximately 52%

of N was retained in the Tenmile Hollow sub-watershed located in the northeastern part of the Lower Suwannee River watershed. Land cover in the Tenmile Hollow sub-watershed is characterized by 39% forest, 41% intensive land uses (e.g. crops, pastures, urban areas), and 6% (39 properties) of the area is occupied by FSPs. Statistical analysis showed that both the Nitrogen retention and export were higher in sub-watersheds with 5- 53% of the total area occupied by FSPs; however, the differences were not statistically significant.

For the Lower Suwannee River watershed, the total amount of phosphorus exported to the stream was 8,051 kg and the total amount retained was 246,756 kg. The largest percentage of phosphorus retained by a sub-watershed was by the Old Grassy Lake sub-watershed, where 96% of the loaded phosphorus was retained. The land use/cover of this sub-watershed is comprised of 57% forest, 29% intensive land use (e.g. crops, pastures, urban areas), and 3% (2 properties) occupied by FSPs. Statistical analysis was performed to identify whether having FSPs in a sub-watershed affects the amount of exported and retained phosphorus. The results indicated that both the phosphorus retention and export were higher in sub-watersheds with 5- 53% of the total area occupied by FSPs; differences were not statistically significant.

Economic Value of Water Resource Protection and Forest Conservation

Nutrient pollution from anthropogenic sources is a leading cause of water impairment in the United States. Forested ecosystems are highly effective in protecting water quality by reducing nutrient loading and soil erosion; however, information about the economic benefits and ecosystem services associated with preserving forested areas is frequently lacking. Quantifying these values is important for making informed policy decisions and designing effective incentive programs to protect water quality. Using a meta-analysis and econometric modeling of 43 observations, we estimate the public's willingness to pay (WTP) for water resource protection and related forest conservation programs. We focus on WTP values associated with water resource and forest conservation programs that protect "well conserved" or relatively unpolluted aquatic systems, which is unique in the literature. Since the Forest Stewardship Program encourages multiple uses and promotes forest conservation, we assume that FSPs are a proxy for forest conservation and water quality protection programs, hence the results can be used to assess the benefits of the Forest Stewardship Program.

Our econometric model had a very high explanatory power and performed well (R^2 = 0.88 and F- Statistic= 28.136). Parameter estimates reveal several important drivers of WTP for water quality protection programs, including: geographic context, type of water protection program, type of aquatic resources, scope of the conservation project (e.g. watershed, statewide), and county-level median income. Our results can be used to inform public choices about water quality incentive programs and payments, and to evaluate cost-effectiveness of alternative policies. For example, when this model was applied to the four Forest Inventory and Analysis (FIA) regions in Florida, we find that annual household WTP ranged from $3.32 to $4.79 for programs that use land acquisition or easement-type strategies for an annual total of 17 million dollars in the state of Florida. For comparison, annual household WTP was much higher ($64.81 to $94.01) for programs that do not use land acquisition or easement (annual total of almost $335 million). The Forest Stewardship Program is similar to these other programs in that it emphasizes resource protection, and according to our results this programs should be able to garner a higher willingness to pay.

These results indicate that Florida citizens interested in protecting water quality in well conserved aquatic systems would likely place a higher value on well-conserved water systems and programs such as the Florida Forest Stewardship Program, compared to programs that remove land from private ownership. This study also indicates that specific water quality protection program strategies and characteristics can have an important impact on individuals' support and WTP for the program, and policy makers should carefully consider these results and the potential for public support and economic resources that can be invested in forest conservation polices that protect water quality.

Carbon Stocks on Forest Stewardship Program and Adjacent Lands

We quantified carbon stocks on FSPs and their economic value and compared estimates with other forests in Florida. This valuation of carbon as an ecosystem service is useful for informing landowners and policy makers on the value of conservation programs and managing forests for multiple uses and for climate regulation. The USDA Forest Inventory and Analysis (FIA) data was used to estimate total, aboveground, belowground, dead, and soil carbon in FSPs and adjacent forests within a mile of FSPs (hereafter referred to as buffers). Results were used to statistically compare FSP values to these adjacent forests.

The average total carbon stock estimated for FSPs in northwestern Florida was 166 Mega grams carbon per hectare; Mg C/ha (ranges from 104 to 266 Mg C/ha), which was higher than the average value (138 Mg C/ha) for the buffer regions (ranges from 32 to 362 Mg C/ha). The economic value of carbon stored on FSPs was based on reported average carbon prices and ranged from $520 to $10,640 per ha with an average value of $3,154 per ha, while the buffer region values ranged from $160 to $14,480 with an average value of $2,622 per ha. The average total carbon stock estimated for FSPs in northeastern Florida was 153 Mg C/ha (ranges from 116 to 245 Mg C/ha), which was higher than the average value (143 Mg C/ha) for the buffer regions (ranges from 17 to 368 Mg C/ha). The economic value of carbon in FSPs ranged from $580 to $9,800 per ha with an average value of $2,907 per ha. The buffer region values ranged from $85 to $15,120 with an average value of $2,717 per ha.

In central Florida, mean total carbon for FSPs was 163 Mg C/ha (ranged from 89 to 237 Mg C/ha), which was lower than 176 Mg C/ha in FSP buffer areas (ranged from 38 Mg C/ha to 308 Mg C/ha). The dollar value of total carbon per ha ranged from $445 to $9,480 (mean= $3,097) in FSPs which was lower than the values in the buffer areas (mean= $3,344, ranged from $190 to $12,320). Due to the few FSPs in south Florida and the lack of FIA plots, we only present the carbon value for forests near those FSPs. We also estimated the total carbon stored in the Suwanee watershed. The carbon value was estimated for 63 sub-watersheds. At the sub-watershed level, the value of total carbon for sub-watersheds ranged from 182 Mg C/ha to 302 Mg C/ha, with an average of 220 Mg C/ha. The total carbon stored in the Lower Suwannee watershed was estimated to be approximately 26 million Mg.

Although carbon values in FSPs for northeast and northwest Florida were higher than adjacent forests, the differences were not statistically significant. The carbon values estimated by this study are close to 74 to 280 Mg C/ha reported by Heath et al. (2011) for the southeastern US. The average total value of carbon stored in average-sized FSPs (96 ha for northwest and 160 ha for south Florida) in all the four FIA regions in Florida (as described above) ranged from $300,000 to $578,000.

Managed Timber Production

Timber production and value were assessed, since 80% of the FSP management plans consider it an important management objective and ecosystem service (Chris Demers, University of Florida, personal communication, November, 2011). Two different methods were used to analyze timber volume on FSP forests and adjacent forests (non-FSPs). The first analysis used FIA data on net volume of timber, net merchantable growth, and the net volume of growing-stock for removal purposes and analyzed these according to FIA geographic regions. Results show that net timber volume ranged from 52.6 to 162.4 m^3/ha and was greater on non-FSP forests in the northwestern and southern Florida FIA units. However, net timber volume was greater on FSP in northeastern and central Florida. Net merchantable growth was greater on FSPs in northeastern and southern Florida but ranged from 1.4 to 6 m^3/ha/year on FSPs and 0.9 to 25.5 m3/ha/year on non-FSPs. The net volume of growing-stock for removal purposes was greatest on FSPs in central Florida and non-FSPs in northeastern and northwestern Florida.

The second method used the InVEST Managed Timber Production model to estimate timber production potential and value of FSPs under different management criteria. This was analyzed by quantifying the amount of timber harvested under different modeling scenarios and determining the economic value of the harvested timber. Specifically, we calculated timber stocks and the economic value of "pine forests" on FSPs for the four FIA geographic regions using the InVEST model using (1) land cover data to identify pine-timber parcels, (2) FSP property boundary data, and (3) FIA data provided by the USDA Forest

Services. The managed timber production model was applied on a representative set of the FSP properties, which included forested properties with an area greater than 25 hectares and that included timber harvesting as a management objective in their Forest Management Plan (FMP).

Two different scenarios were created to simulate different forest management criteria: the first scenario considered FSP forest/timber management, and the second one considered non-FSP forest/timber management criteria. Our definition of FSP criteria assumed that thinning was applied at the rate of 1-3 times per rotation for landowners that manage for multiple uses and each thinning treatment was assumed to remove 30% of the total timber biomass per hectare. The non-FSP scenario assumed no thinning treatment. The FSP and non-FSP scenarios produced the same timber volume in cubic meters for the four FIA units. In terms of economic value, the largest revenue was achieved for the non-FSP scenario and was a due to the greater amount of timber available for harvest at a higher price. However, according to timber production comparative analysis results, there was no significant difference between FSP and non-FSP management scenarios as they differed mainly in the use of thinning activities.

Species Conservation Value of Non-Industrial Private Forestlands

The economic value of conserving habitat for threatened or endangered wildlife was estimated for Florida Forest Stewardship Program (FSP) lands using "non-use values". These non-use use values represent the benefits people receive from the conservation of key wildlife species through the FSP. Non-use values, together with the direct use values from wildlife-associated recreation make up the total economic value of wildlife. The non-use use value of FSP for species conservation depends on the extent to which the management of lands under the FSPs improves habitat quality and quantity and, ultimately, the effect these improvements have on the size of the populations of these species in the state.

This study estimated how much Florida households would be willing to pay to prevent the declines in certain wildlife species populations avoided because of the existence of the FSP. Willingness to pay (WTP) measures net benefits to people and is commonly used to measure non-use use values. The economic analyses were based on "benefit transfers" that apply existing economic value estimates from original study sites to FSP lands for which existing estimates are not available. We determined the wildlife habitat conservation value of FSP lands by reviewing relevant literature on people's WTP for conserving threatened, endangered or rare wildlife species. The literature provides WTP values for two species found on FSP lands: the red-cockaded woodpecker and the bald eagle. Three additional species found on FSPs for which no WTP studies exist were also included in the analysis: the Florida black bear, the gopher tortoise and the Florida scrub-jay.

We estimated the effect of FSPs on species populations using spatial analysis to overlay FSP and statewide potential habitat for the five species. We found that for each of the species, potential habitat on FSP accounts for less than 1 percent of potential habitat in the state. Analyzed population changes were one to two orders of magnitude smaller than those examined in the literature. An expert interview process was then used to estimate the avoided reductions in the populations of the five species achieved through the FSP, assuming that without the FSP these lands would be converted. Two experts each for the gopher tortoise and Florida black bear and three experts each for the Florida scrub-jay, red-cockaded woodpecker, and bald eagle were used. Expert opinion indicated that FSPs provided relatively small benefits in terms of avoided population losses (0-5%), since only a small portion of total statewide potential habitat of each these five species is located on Florida FSPs. However, even though small, these avoided losses do carry economic value. Experts were unable to estimate avoided losses for the Florida black bear and gopher tortoise.

Finally, economic benefits were estimated using three different approaches. First, a point value transfer of existing WTP estimates for the bald eagle -- adjusted for household income and species population changes between the literature study sites and Florida -- generated WTP estimates for avoided losses to populations found on FSP lands. Second, a statistical function based on more than 30 original species valuation studies in the US and appropriate for Florida was applied to estimate WTP for a change in a species' population based on species characteristics, size of population change, and other variables identified as significant in existing studies. This approach yields WTP estimates for avoided losses in the populations of bald eagles, red-cockaded woodpeckers, and Florida scrub-jays. Third, we used the WTP estimates for the bald eagle derived in the first approach and scaled these to the red-cockaded woodpecker and Florida scrub-jay by using ratios of conservation expenditures for these same species. This approach relies on the well-established observation that spending for species protection is a result in part of the value people place on individual species. Total expenditures by the US Fish and Wildlife Service and the Florida Wildlife Conservation Commission for 1994-2009 were used for this scaling approach. Value estimates could not be developed for the Florida black bear or the gopher tortoise, due to the lack of estimates of the effect of FSP lands on these species' populations.

Our overall mean estimate of the total statewide lump sum WTP for the avoided population losses in bald eagles, red-cockaded woodpeckers and Florida scrub-jays expected to result from the FSP lands is $54 million, which translates to a one-time payment of about $7.65 for 50 % of the average households in Florida. The different valuation approaches and population change methods resulted in estimates of the combined statewide economic value of avoided losses of bald eagles, red-cockaded woodpeckers and Florida scrub-jays through forest conservation that ranged from $5.9 million to $128 million, indicating a large range in our mean estimates.

FULL REPORTS

Public Land Management Agencies' and Non-industrial Private Forest Landowners' Perceptions towards Ecosystem Services

Taylor Stein, Namyun Kil, Alexis Frank (University of Florida)

Introduction

As researchers and policy makers talk about the wealth of ecosystem services provided to society by natural resources and their proper management, little research has been conducted on how the people making the decisions think about the variety of existing and potential services provided by lands they manage. Researchers have assessed and quantified the provision of specific ecosystem services (e.g., carbon sequestration, water quality, and others), but a specific survey of Florida land managers and decision-makers and their general attitudes towards "ecosystem services" has not been conducted. This component of the project had several objectives for two different populations:

1. Public Land Management Agency Decision-makers
    - Clarify what public land management agency decision-makers consider to be ecosystem services and
    - Identify and prioritize the most relevant ecosystem services to public land management agency decision-makers.
2. Non-industrial Private Forest (NIPF) Landowners
    - Identify the importance of ecosystem services to non-industrial private forest landowners,
    - Identify NIPF landowners' attitudes towards ecosystem service concepts and characteristics,
    - Understand NIPF landowners' reasons for owning forested land, and
    - Clarify the recreation activities and experiences NIPF landowners hope to attain from their land.

Methods

University of Florida researchers developed two questionnaires to collect data from two forestland management groups: (1) public land management agency decision-makers and (2) non-industrial private forest (NIPF) landowners. Together, these two populations manage the majority of Florida's forests; therefore, their knowledge about ecosystem services and how they manage for, and prioritize, specific ecosystem services is important for understanding the role of "ecosystem services" in Florida land management decision-making.

Study Participants

Researchers attempted to survey every major public land management agency in Florida. For agencies that had a central headquarters for Florida (most state agencies and the U.S. Forest Service's National Forests in Florida), the head of the agency or the person responsible for land management decision-making was included in the survey. Researchers also wanted responses from city and county governments, but most Florida cities and counties do not have specified land management programs; therefore, researchers surveyed the state's counties and identified counties and cities with land management offices that could be included in the survey. Representatives from 27 agencies were included in the survey, and 23 people responded (87% response rate). Over half the sample included county level representatives, but most state agencies replied, and only one federal agency (US Forest Service) responded. For the NIPF landowners, participants were solicited from the UF Florida Forest Stewardship Program coordinator. The Florida stewardship program is the largest forest landowner education program in Florida. An e-mail was sent to 527 participants; 194 people responded, for a response rate of 37%.

Questionnaires

Both questionnaires were designed to gain basic descriptive information from the respondents. Questions were developed from a variety of sources. In particular the type of specific ecosystem services used in both questionnaires was modified based on research conducted by de Groot et al. (2002). For the public land management agency decision-makers, questions asked participants to list and identify what they perceived as their agencies' most important or highest priority, ecosystem services. The questionnaire for NIPF landowners addressed how they felt about the importance of a variety of ecosystem services. A variety of other questions were asked to assess socio-demographic descriptions of the landowners, type and intensity of management practices they conduct, and finally knowledge and concern for concepts associated with overall ecosystem services such as biodiversity, carbon sequestration, and recreation opportunities on their property.

Results

Public Agency Survey Results

Results show that representatives of Florida's public land management agencies place a high priority in recreation and scenery and they believe that their general management of habitat and natural resources is essential to maintain ecosystem services (Figure 1). After being provided with the definition of "ecosystem service" as "components of nature, directly enjoyed, consumed, or used to yield human well-being"; the majority of comments were related to "habitat/natural resources conservation and management" and recreation."

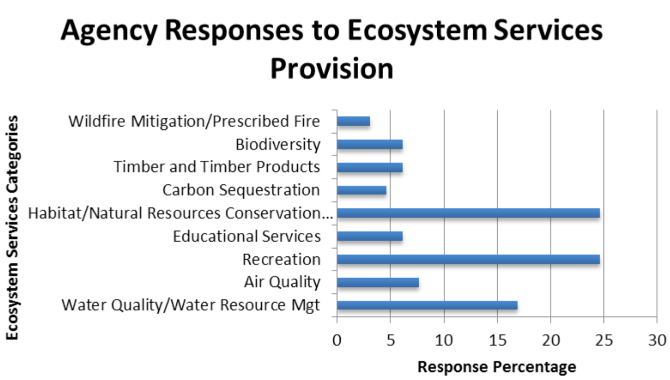

Figure 1. Open responses to ecosystem services provided by lands managed by public agencies

Using a list of specific ecosystem services, respondents rated which of those services they considered to be their agencies' main priorities (Table 1). "Overall environmental quality for recreation opportunities" and "enjoyment of scenery" was most often rated as agencies' first through fifth highest priorities. The category "Other" was also commonly listed as a high priority. In many cases, participants referred to ecosystem services already listed, but used wording that they believe more accurately reflected how their agency considers the management of that service. Representatives also listed more general types of management activities including prescribed fire, habitat restoration, and others (Figure 2).

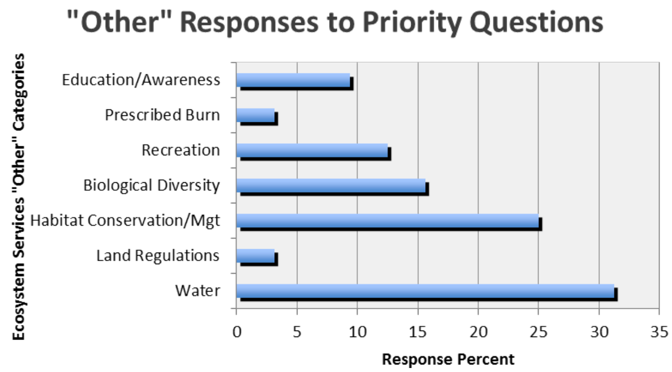

Figure 2. Responses to "Other" ecosystem services

Private Land Survey Results

As stated earlier for the NIPF landowners, participants were solicited from the coordinator of the Florida Forest Stewardship Program. They were asked whether they own or manage undeveloped private land in Florida, and whether they have participated in various programs. A majority of the participants (88.7%) said they owned or managed undeveloped private land in Florida. Also, respondents reported 'Florida Forest Stewardship Program' (66.9%), 'County Foresters (Florida Division of Forestry)' (49.4%), and 'Florida Cooperative Extension Services' (33.7%) as the most common programs/organizations they participated in (Table 2).

Respondents' Management and Land Use History

Participants were asked a series of questions related to their land use history (Tables 3, 4, and 5). More than 70 % of respondents reported that they were likely to personally have owned/managed the land for at least 8 years, and their family had also owned or managed the land for 8 years or more. Almost half of respondents (46.4%) currently live on the forest land they manage, and more than half of respondents (52.2%) earned 1% or more of their annual household income from the land they own or manage. Half of respondents (49.3%) also reported to currently manage 48-349 acres of land (Table 3).

Table 1. Agencies' top five priority ecosystem services

Answer Options	First Priority Percent (Count)	Second Priority Percent (Count)	Third Priority Percent (Count)	Fourth Priority Percent (Count)	Fifth Priority Percent (Count)
Overall Environmental Quality for Recreation Opportunities	40.9% (9)	13.6% (3)	22.7% (5)	9.1% (2)	4.5% (1)
Other (please specify)	36.4% (8)	31.8% (7)	31.8% (7)	18.2% (4)	27.3% (6)
Flood Prevention	9.1% (2)	13.6% (3)	13.6% (3)	4.5% (1)	4.5% (1)
Quality of Drinking Water	9.1% (2)	9.1% (2)	9.1% (2)	13.6% (3)	0.0%
Timber	4.5% (1)	0.0%	0.0%	9.1% (2)	0.0%
Enjoyment of Scenery	0.0%	13.6% (3)	9.1% (2)	22.7% (5)	13.6% (3)
Water Quality and Quantity in Recreation/Tourism Sites	0.0%	9.1% (2)	4.5% (1)	9.1% (2)	0.0%
Maintenance of Air Quality	0.0%	4.5% (1)	0.0%	9.1% (2)	0.0%
Non-Timber Forest Products	0.0%	4.5% (1)	0.0%	0.0%	0.0%
Water Used for Crop Irrigation	0.0%	0.0%	4.5% (1)	0.0%	0.0%
Control of Pests and Diseases	0.0%	0.0%	4.5% (1)	0.0%	4.5% (1)
Terrestrial Carbon Storage and Sequestration to Mitigate Global Climate Change	0.0%	0.0%	0.0%	4.5% (1)	18.2% (4)
Crop/Agricultural Production	0.0%	0.0%	0.0%	0.0%	13.6% (3)
Prevention of Damage from Erosion/Siltation	0.0%	0.0%	0.0%	0.0%	9.1% (2)
Abatement of Noise Pollution	0.0%	0.0%	0.0%	0.0%	4.5% (1)
Pollution Control/Detoxification	0.0%	0.0%	0.0%	0.0%	0.0%
Pollinator Abundance in Agricultural Fields	0.0%	0.0%	0.0%	0.0%	0.0%
Small-Scale Subsistence Hunting	0.0%	0.0%	0.0%	0.0%	0.0%
Drugs and Pharmaceuticals	0.0%	0.0%	0.0%	0.0%	0.0%
Answered Question	**22**	**22**	**22**	**22**	**22**
Skipped Question	**1**	**1**	**1**	**1**	**1**

Table 2. Respondents' involvement with managing undeveloped private lands in Florida and participation in various programs

Statement	n	Label	Valid Percent (%)
Own/manage undeveloped private land in Florida	194	Yes	88.7
		No	11.3
Participation in/with various programs/organizations	172	Florida Forest Stewardship Program	66.9
		County Foresters (Florida Forest Service)	49.4
		Florida Cooperative Extension Services	33.7
		Tree Farm Program	33.1
		USDA Assistance or Cost-Share Programs	32.6
		Florida Farm Bureau	25.0
		Florida Fish and Wildlife Conservation Commission Assistance or Cost-Share Programs	24.4
		Florida Forestry Association	18.6
		Soil and Water Conservation District	12.2
		Florida Cattlemen's Association	8.7
		Forest Landowners Association	8.7
		Other	5.8

Table 3. Respondents' land use history I

Statement	n	Label	Valid Percent (%)
Years you personally owned or managed the land	152	1 - 7 years	29.6
		8 - 27 years	44.1
		28 years or more	26.3
Years your family owned or managed the land	143	1 - 7 years	29.4
		8 - 27 years	44.1
		28 years or more	26.6
Currently living on the forest land you manage	151	Yes	46.4
		No	53.6
Percentage of your annual household income from your land	142	0%	47.9
		1 - 6%	26.8
		7% or more	25.4
Acres you currently own/manage	152	1 - 47 acres	25.0
		48 - 349 acres	49.3
		350 acres or more	25.7

For the number of acres they currently have for various uses, results show that a minor number of respondents were reported to have at least 1 acre of land for 'crop (non-timber) production' (21.8%), 'livestock production' (25.7%), 'marsh/non-forested wetland' (36.2%), and 'other land use' (38.1%), each. However, more than half of respondents reported that their current land is used for 'planted forest' (53.3%) and 'natural forest/forested swamp' (57.2%) (Table 4).

In addition, about one-third of respondents were more likely to use their own land primarily for timber (61.1%), and a small number of respondents owned their land for agriculture (12.0%) and recreation (15.4%) (Table 5). More than half of the respondents used their land for hunting for themselves and their family/friends (59.3%), less than a quarter of respondents lease their land for hunting (22.7%), and more than 60 percent of respondents who currently have hunting leases earn up to $2,500 annually from their hunting leases (64.4%).

Table 4. Respondents' land use history II

Statement	Acres (Valid Percent %)				
Acres you currently have in various uses	n	0 acre	1 - 100 acres	101 - 300 acres	301 acres or more
Crop (non-timber) Production	151	78.1	17.9	2.6	1.3
Livestock Production	152	74.3	19.1	3.3	3.3
Planted Forest	152	16.4	53.3	17.8	12.5
Natural Forest/Forested Swamp	152	22.4	57.2	10.5	9.9
Marsh/Non-Forested Wetland	152	63.8	32.9	1.3	2.0
Other Land Use	152	61.8	36.8	0	1.3

Table 5. Respondents' land use history III

Statement	n	Label	Valid Percent (%)
Primary use of your own land	149	Agriculture	12.0
		Timber	61.1
		Recreation	15.4
		Other	11.4
Land used for hunting by you/your family/friends	150	Yes	59.3
		No	40.7
Land leased out for hunting	150	Yes	22.7
		No	77.3
Annual amount earned from hunting leases	34	Less than$500	23.5
		$500 -$999	17.6
		$1,000 -$2,499	23.5
		$2,500 -$4,999	11.8
		$5,000 -$9,999	11.8
		More than$10,000	11.8

Familiarity with Ecosystem Concepts and Reasons for Owning their Forested Land

Respondents were asked to rate (1) how familiar they are with ecosystem service related concepts and (2) important reasons for owning forested land. More than half of the respondents were aware of ecosystem service concepts such as wildlife habitat (77.3%, mean = 2.66), water quality (60.9%, mean = 2.47), and biodiversity (59.1%, mean = 2.36). Over 40% of the respondents were not familiar with the specific terms "ecosystem services" (43.0%, mean = 1.91) and "carbon storage" (45.9%, mean = 1.80) (Table 6).

A majority of respondents reported enjoyment of beauty and protection of nature as important reasons for owning their forested land (87.3%, mean = 2.82). Many respondents owned land for land investment (63.6%, mean = 2.46) and participation in their own recreation activities (65.5%, mean = 2.44), and half of respondents owned land as a part of their home or vacation home (54.5%, mean = 2.20). Finally, more than one-third of respondents were reported to own their forested land in order to generate income from timber or hunting leases (37.7%, mean = 1.89) (Table 7).

Table 6. Familiarity with ecosystem service concepts

Management Activity Concept[a]	n	Not Familiar (%)	Neutral (%)	Familiar (%)	Mean	SD[b]
Wildlife habitat	150	11.3	11.3	77.3	2.66	.67
Water quality	151	13.9	25.2	60.9	2.47	.72
Biodiversity	149	22.8	18.1	59.1	2.36	.83
Ecosystem services	151	43.0	22.5	34.4	1.91	.87
Carbon storage	148	45.9	28.4	25.7	1.80	.82

[a]Items were coded 1 = not familiar, 2 = neutral, and 3 = familiar (mean refers to average of the three values).

[b]Standard deviation

Table 7. Important reasons for owning forested land

Reasons for Owning Forested Land[a]	n	Not Important (%)	Neutral (%)	Important (%)	Mean	SD[b]
Enjoy beauty/protect nature	150	5.3	7.3	87.3	2.82	.50
Land investment	151	17.9	18.5	63.6	2.46	.78
Participate in your own recreation activities	148	21.6	12.8	65.5	2.44	.82
Part of my home or vacation home	143	34.3	11.2	54.5	2.20	.92
Generate income from timber or hunting leases	151	48.3	13.9	37.7	1.89	.92

[a]Items were coded 1 = not important, 2 = neutral, and 3 = important (mean refers to the average of three values).

[b]Standard deviation

Importance of Ecosystem Services and Ecological Characteristics

Researchers sought to better understand the variety of ecosystem services and benefits provided to society, and the survey contained questions to identify what landowners considered to be important ecosystem services and ecosystem characteristics when managing their land.

A majority of respondents considered various ecosystem services such as enjoyment of scenery (84.5%, mean = 2.79), quality of drinking water (75.0%, mean = 2.63), overall environmental quality for recreation opportunities (72.8%, mean = 2.61), and timber (71.6%, mean = 2.59) important to them when managing their land. Other ecosystem services considered important included biodiversity of plant and animal species (66.2%, mean = 2.55), maintenance of air quality (62.2%, mean = 2.47), and control of pests and diseases (60.7%, mean = 2.46) (Table 8). Over half of the respondents said crop/agricultural production (51.7%, mean = 1.80), water used for crop irrigation (64.3%, mean = 1.57), and drugs and pharmaceuticals (74.5%, mean = 1.35) were not important.

Table 8. Importance of ecosystem services when managing land

Ecosystem Services[a]	n	Not Important (%)	Neutral (%)	Important (%)	Mean	SD[b]
Enjoyment of scenery	148	5.4	10.1	84.5	2.79	.52
Quality of drinking water	148	12.2	12.8	75.0	2.63	.69
Overall environmental quality for recreation opportunities	147	11.6	15.6	72.8	2.61	.68
Timber	148	12.8	15.5	71.6	2.59	.70
Biodiversity of plant and animal species	148	10.8	23.0	66.2	2.55	.68
Other	15	20.0	6.7	73.3	2.53	.83
Maintenance of air quality	148	15.5	22.3	62.2	2.47	.75
Control of pests and diseases	145	15.2	24.1	60.7	2.46	.74
Water quality and quantity in recreation/tourism sites	145	22.1	20.7	57.2	2.35	.82
Prevention of damage from erosion/siltation	146	25.3	15.8	58.9	2.34	.85
Pollinator abundance	143	25.9	25.2	49.0	2.23	.83
Pollution control/detoxification	145	29.7	20.7	49.7	2.20	.87
Small-scale hunting	146	37.7	15.1	47.3	2.10	.92
Flood prevention	149	34.9	29.5	35.6	2.01	.84
Abatement of noise pollution	144	39.6	22.9	37.5	1.98	.88
Carbon storage to mitigate global climate change	145	43.4	20.7	35.9	1.92	.89
Non-timber forest products	145	48.3	22.1	29.7	1.81	.86
Crop/agricultural production	143	51.7	16.1	32.2	1.80	.89
Water used for crop irrigation	143	64.3	14.7	21.0	1.57	.81
Drugs and pharmaceuticals	145	74.5	15.9	9.7	1.35	.65

[a]Items were coded 1 = not important, 2 = neutral, and 3 = important.

[b]Standard deviation

Respondents appeared to have similar attitudes towards a variety of specific ecological characteristics related to ecosystem services. Over 50% of the participants believed each of the characteristics were important. This included both healthy pine plantations (82.4%, mean = 2.75) and many different wildlife species (78.6%, mean = 2.67), which were the two highest rated characteristics (Table 9).

Recreation Activities and Experiences

Recreation is often listed as an important reason for owning forests, but little research has been conducted to understand the underlying activities and motivations for why and how private forest landowners use their land for recreation. Researchers asked them a few questions about their recreation activities and experiences on their land (Tables 10 and 11).

Respondents were asked how often they use their land for recreation purposes. Many respondents were reported to participate in recreation activities on their land for several days a month or more frequently (e.g., almost every day, every day) (61.9%). In addition, recreation activities that most respondents have participated in, or plan to do, on their land included wildlife viewing (86.5%), day hiking/walking (83.7%), and viewing scenery (77.3%) (Table 10).

Table 9. Importance of ecological characteristics

Ecological Characteristics[a]	n	Not Important (%)	Neutral (%)	Important (%)	Mean	SD[b]
Healthy pine plantations	148	7.4	10.1	82.4	2.75	.58
Many different wildlife species	145	11.7	9.7	78.6	2.67	.67
Other	13	15.4	7.7	76.9	2.62	.76
Large numbers of game animals (e.g., deer, turkey, etc.)	148	10.8	16.9	72.3	2.61	.67
Controlled, managed natural areas	148	14.9	11.5	73.6	2.59	.73
Many different ecosystems (e.g., wetlands, pinelands, etc.)	145	15.9	17.9	66.2	2.50	.75
Many different plant species	147	20.4	16.3	63.3	2.43	.81
Pristine conditions with little evidence of humans	146	26.7	19.2	54.1	2.27	.85

[a]Items were coded 1 = not important, 2 = neutral, and 3 = important.

[b]Standard deviation

Table 10. Landowner participation in recreation activities

Statement	n	Label	Valid Percent (%)
Frequency of using your land for recreation purposes	150	Never	4.7
		1 - 5 days a year	8.7
		6 - 10 days a year	12.0
		Once a month	12.7
		Several days a month	29.3
		Several days a week	13.3
		Almost every day	11.3
		Every day	8.0
Recreation activities done/to do at your land	150	Wildlife Viewing	86.5
		Day Hiking/Walking	83.7
		Viewing Scenery	77.3
		Hunting	54.6
		Nature Study	52.5
		Photography	49.6
		Fishing	31.2
		Camping	29.8
		Picnicking	28.4
		Jogging/Trail Running	19.9
		Horseback Riding	17.0
		Other	12.8
		Canoeing/Kayaking	10.6
		Swimming	10.6
		Mountain Biking	7.8

Although understanding the activities in which people participate in natural areas is important, recreation researchers have found that understanding participants' motivations provides a more holistic understanding of recreation participation. Motivations are the final outcome of participating in recreation and are the reason why recreation activities are desired in the first place (Manning, 1998; Stein and Lee, 1995). Therefore, respondents were asked to rate many different recreational motivations for using their land. Most respondents reported being close to nature (85.7%, mean = 2.81), enjoying the scenery (83.3%, mean = 2.78), experiencing nature (82.9%, mean = 2.76), viewing the scenic beauty (72.9, mean = 2.65), and escaping from the "usual demands of life" (75.4, mean = 2.64) as the most important reasons for using their land. Experiences such as group bonding, thrill, skill tests, and spirituality were reported as the least important reasons for using their land (Table 11).

Table 11. Importance of landowner recreation experiences

Recreation Experiences[a]	n	Not Important (%)	Neutral (%)	Important (%)	Mean	SD[b]
To be close to nature	140	5.0	9.3	85.7	2.81	.50
To enjoy the scenery	138	5.8	10.9	83.3	2.78	.54
To experience nature	140	6.4	10.7	82.9	2.76	.55
To view the scenic beauty	133	8.3	18.8	72.9	2.65	.63
To get away from usual demands of life	138	10.9	13.8	75.4	2.64	.67
To learn more about the nature	139	7.9	23.0	69.1	2.61	.63
To learn about the natural environment of the area	136	11.0	28.7	60.3	2.49	.68
To feel healthier	134	14.9	21.6	63.4	2.49	.74
To relax physically	138	15.9	21.0	63.0	2.47	.75
To be on my own	136	19.9	23.5	56.6	2.37	.79
To do something with my family	134	23.1	17.2	59.7	2.37	.83
To explore the area	137	19.0	27.0	54.0	2.35	.78
To get exercise	136	17.6	30.1	52.2	2.35	.76
To experience solitude	137	21.9	24.1	54.0	2.32	.81
To think about personal values	134	29.9	23.9	46.3	2.16	.86
To be away from people	135	30.4	24.4	45.2	2.15	.86
To develop personal, spiritual values	136	29.4	28.7	41.9	2.13	.83
To use my own equipment	136	33.1	25.7	41.2	2.08	.86
To experience new and different things	135	35.6	25.2	39.3	2.04	.86
To share my skills and knowledge with others	134	33.6	29.1	37.3	2.04	.84
To be with people having similar values	137	37.2	27.7	35.0	1.98	.85
To grow and develop spiritually	134	38.1	26.9	35.1	1.97	.85
To be with people who enjoy the same things I do	137	43.1	24.8	32.1	1.89	.86
To test my skills and abilities	136	44.1	23.5	32.4	1.88	.87
To have thrills and excitement	135	56.3	23.0	20.7	1.64	.80
To be with members of my group	134	59.0	19.4	21.6	1.63	.82

[a] Items were coded 1 = not important, 2 = neutral, and 3 = important.

[b] Standard deviation

Finally, respondents were asked about the kinds of recreation activities on their private land that might be enjoyed by the general public if they opened their land to the public. Respondents reported that day hiking and walking (77.6%), wildlife viewing (74.8%), and nature study (73.5%) would be the most common activities for the public to enjoy. Additional common activities reported by about one-third of respondents included viewing scenery (68.7%), photography (65.3%), and hunting (60.5%). The least common activities that might be enjoyed by the public were reported to be mountain biking (18.4%), canoeing/kayaking (13.6%), and swimming (10.2%) (Table 12).

Table 12. Recreation activities that might be enjoyed by the general public (n=47)

Statement	Label	Valid Percent (%)
Recreation activities done/to do at your land	Day Hiking/Walking	77.6
	Wildlife Viewing	74.8
	Nature Study	73.5
	Viewing Scenery	68.7
	Photography	65.3
	Hunting	60.5
	Camping	55.1
	Picnicking	51.7
	Horseback Riding	40.8
	Jogging/Trail Running	34.7
	Fishing	32.7
	Mountain Biking	18.4
	Canoeing/Kayaking	13.6
	Swimming	10.2
	Other	9.5

Discussion

The surveys of both public and private land managers show that ecosystem services such as aesthetics and recreation are of high importance. Specifically, scenery and recreation were clear priorities for management and were considered some of the most important ecosystem services provided on both public and private lands. Timber and ecosystem services related to water (e.g., quality drinking water) were also important for both public and private managers. However, the survey also showed there were many issues related to ecosystem services that both public and private managers do not consider or prioritize when managing their lands. Plentiful research exists that shows a multitude of benefits provided by forests (Constanza et al. 1997; de Groot et al. 2002); however, most of these commonly reported ecosystem services did not seem to be top priorities for Florida public managers. In contrast, NIPF landowners did consider most commonly reported ecosystem services as important; however, with the exception of drinking water quality, they still focused on the more traditional uses of private lands (e.g., recreation and timber). Both surveys will be discussed separately below.

Public Land Management Agencies Survey

The sample for public land management agency representatives was rather small, but did provide a perspective of the majority of public agencies in Florida. In particular, county agencies were well represented, which is not a group often addressed in surveys. Besides the focus on recreation, scenery, and timber, no other ecosystem service was considered a top priority except for water quality and flood prevention. Water quality and flood prevention are primary missions for water management districts, but other agencies also consider these services to be important services they help to provide to society.

The wealth of other services not considered to be priorities or only mentioned as fourth and fifth priorities might provide a direction for policy makers and forest education providers. These are potential areas to highlight in educational programs and activities since many of these are essential and valuable ecosystem services for the public. For example, "terrestrial carbon storage and sequestration to mitigate global climate change" was not listed as an important priority until asked about their fourth highest priority, and only four respondents listed it as their agencies' fifth highest priority. Other services likely produced on public lands like non-timber forest products, prevention of damage from erosion and sedimentation, pollution control and detoxification, and others are provided by public lands but not considered priorities.

NIPF Landowners Survey

NIPF participants were also asked about ecosystem services, but in a slightly different way. Instead of listing their priority services, NIPF participants ranked the importance of each ecosystem service. Other questions targeted landowners' priorities for specific management practices. Results show that participants generally consider most ecosystem services as important. Since most of these items were listed in a positive way and likely benefit the landowners, themselves, or adjacent residents, it is not surprising that participants would have favorable attitudes towards most services. Like the priority ecosystem services for public agency representatives, NIPF landowners similarly rated recreation, scenery, and timber services the most important because they are consistent with traditional practices. In fact, when asked about their primary uses of their land, most respondents listed timber (see Table 5) and enjoying beauty/protect nature and participate in recreation activities as important uses of their land (see Table 7). "Quality of drinking water" received the second highest importance score for the ecosystem services, with 75.0% of respondents listing it as important.

Most ecosystem services identified as important had a direct connection to forests. However, "quality of drinking water" has a more indirect relationship, and likely impacts many more people than just the landowner. In fact, water quality is typical of most ecosystem services that provide long-term regional benefits to society. Therefore, it's unique among the highest rated ecosystem services for this survey. This suggests that respondents might believe that the water quality they and surrounding residents enjoy is directly related to their forests. Also, results show that most participants are familiar with the term, "water quality," so this might help to explain why they see a connection between their land and this service.

Like the public land management agency participants, it is useful to look at the ecosystem services participants did not rank highly. In particular, "carbon storage to mitigate global climate change" did not get high importance scores. In fact, only 37.5 % of respondents thought it was an important ecosystem service. There are a number of reasons why carbon storage received such low scores, but Table 6 shows only about one-quarter of participants are familiar with the term "carbon storage." This indicates that unfamiliarity with the concept likely relates to their low awareness of the importance of this value. Other services like "non-timber forest products" represented industries private landowners are likely not involved in; therefore, they do not see those services as important to the management of their forests.

Much research has examined recreation preferences and motivations on public lands, but little research has examined recreation from the private landowner's perspective regarding their own property. Results show that participants frequently participate in recreation activities on their property. Over half participate at least several days a month and only about 5% never participate in recreation on their property. They chose activities that directly relate to the natural characteristics of the land with over 80% of respondents saying they view wildlife and hike or walk on their property. Both activities are heavily reliant on natural ecosystems with little infrastructure. Water-based recreation (e.g., swimming and canoeing/kayaking) received low participant ratings, likely because of the lack of water-based recreation opportunities on their property.

The reasons (i.e., motivations) respondents said they participate in these activities focus on experiencing nature and scenery. In other words, they choose activities that allow them to personally experience the natural aspects of their property and view its scenery. These results are slightly different than past research on recreationists surveyed on public lands (Driver, 2008). In particular, private landowners tend to focus on similar types of experiences and don't value other experiences such as learning, exercise, and spending time with family. In fact, most social benefits (e.g., "to be with members of my group," "to be with people who enjoy the same things I do," and "to be with people having similar values") received some of the lowest scores of the 26 motivations included in the survey. These findings indicate that participants consider their properties to be a "refuge" or "escape" from people where they can concentrate on the nature, wildlife, and scenery.

Key Management Implications

Results of the two surveys show that public land managers and environmental educators who work with private landowners have a good baseline for future work. Public and private landowners already appreciate many ecosystem services, but their management priorities focus on only a few key ecosystem services: recreation/scenery, water, and timber. Future management and education programs can build upon these existing priorities and target new priorities by raising awareness and knowledge on other less known or recognized ecosystem services and their value.

Public and private managers already have a good understanding of managing for timber as an ecosystem service, but it is likely that either group has had little to no training in recreation and aesthetics management. More detailed needs analyses should be developed to identify what managers might need to know to better manage for recreation and aesthetic services, and the methods by which they would like to attain that information. Similarly, private landowners might also have a need to improve the scenery and recreation opportunities on their own properties. Workshops related to scenery, trail management, and watchable wildlife opportunities could be highly attended by private landowners, but future research should be conducted to quantify what landowners might specifically want to learn.

Public and private respondents listed water-related services as priorities or important. Although public land management agencies might understand how management techniques translate to water quality and flood control, private land managers might not have understood the important connection between forest management and water quality. Educational programs should be developed that highlight forest management and water quality in the context of managing NIPF.

Public land managers only listed a few ecosystem services as priorities. Although public land management agencies cannot manage for all ecosystem services specifically, agencies could potentially expand or better recognize the services they prioritize. Carbon sequestration, pollution and erosion control, and the production of non-timber products were not listed as priorities or received very little response by public land management agencies. Understanding why agencies do not consider these services as priorities can help to identify mechanisms (e.g., education, identification of markets, or technological innovation) to help make them greater priorities.

In many cases, agencies might already believe they are providing for these ecosystem services without making them priorities. Researchers included ecosystem services that likely exist on all types of forests, but agencies might not include them as specific objectives in their management or communications with key stakeholders or decision-makers. If this is the case, these agencies could improve their image with the public and decision-makers by highlighting the diversity of ecosystem services produced on public lands.

NIPF participants listed most ecosystem services as important; however, the survey did not identify if landowners manage their lands for specific ecosystem services. Future research could examine if and how a diversity of ecosystem services fit into private landowner's management plans and activities. Future education programs can be developed to help highlight the importance of a greater diversity of ecosystem services, as well as identify appropriate ways to manage for these ecosystem services. Most of the results presented here about private landowners will apply to landowners participating in the Florida Forest Stewardship Program. Results from this study will also be useful in educating those landowners so that they are encouraged to manage their property for a variety of ecosystem services.

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Water Purification: Nutrient Retention

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Introduction

Non-point source nutrient pollution in water bodies is a result of mostly anthropogenic influences such as population growth, chemical uses in agricultural lands, forestry activities, and land use conversions. Although nutrients are necessary for plant and animal growth, increased levels can become problematic particularly when concerning water quality (US EPA 2011). As water flows across the land, its physical and biochemical characteristics are shaped by human activities and the vegetative cover on the landscape (Conte et al. 2011). Therefore determining the effect of land use/cover types on water quality and yield is important. In addition, riparian forest ecosystems are effective nutrient sinks and buffers for nutrient discharge from surrounding ecosystems (Lowrance et al. 1984). Upland forests also retain nutrients and sediments released and transported by surface flows, thus vegetation can help to mitigate pollution downstream (Conte et al. 2011).

The InVEST Water Purification model was used for estimating the contribution of vegetation and soils to purifying water through the removal of nutrient pollutants from runoff. This model has three components: (1) Water yield, (2) Nutrient retention (i.e. biophysical model) and (3) Valuation. The biophysical model uses data on water yield, land cover (LC), nutrient loading, vegetation filtration rates, and water quality standards to determine nutrient retention capacity for current and future land use scenarios. The valuation component of the model uses water treatment cost data and a discount rate to determine the value contributed by the ecosystems on the watershed to the purification of water (Tallis et al. 2011). The specific objectives of this analysis are to:

Quantify the nutrient (Nitrogen and Phosphorus) retention ecosystem service provided by FSP properties in the Lower Suwannee River watershed.

Determine the economic benefit (avoided cost) that the ecosystems provide in terms of nutrient filtration.

Methods

Study area and data

The InVEST Water model was applied in the Lower Suwannee River Watershed in Florida (Figure 1). The Lower Suwannee is one of five watersheds that comprise the Suwannee River watershed (Crane 1986, cited by Katz 2007). We chose the Lower Suwannee watershed for our analysis due to its hydrological nature-- the Suwannee is the second largest river in Florida in terms of average discharge (Light et al. 2002) and the presence of multiple private forests managed under the FSP (15% of the total number of FSP properties are within the Lower Suwanee River Watershed's boundaries). This area is characterized by karstic wetlands, lowland topography, and a small number of tributary streams. The watershed also comprises much of the upper Floridan aquifer springs. The land cover type in the watershed is predominantly forest, agriculture, and wetlands (Ham and Hatzell 1996, cited by Katz 2007). The Lower Suwannee River watershed is divided into 63 sub-watersheds. The input data used by the InVEST water model are presented in Appendix 1, along with parameter descriptions, units of measurement, data sources, and data formatting methods.

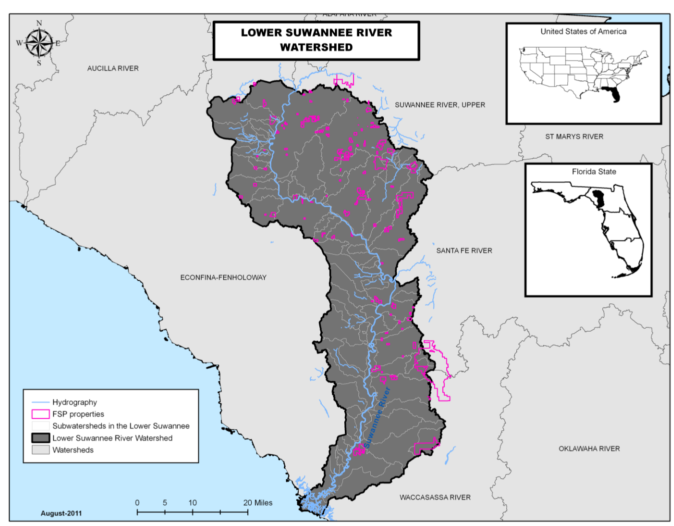


Figure 1. The Lower Suwannee River Watershed, Florida

The InVEST model works in three steps. First, the model calculates the annual average runoff (water yield) for each sub-watershed. Second, the model calculates the quantity of nutrient retained by each sub-watershed by using nutrient loading inputs to calculate how much nutrient is exported to the stream. Third, the model determines how much of the load is retained by each downstream pixel as surface runoff moves the nutrient toward the stream (based on the type of vegetation and its retention capacity). Finally, the amount of ecosystem service provision is estimated using the amount of allowed nutrients (critical load) in the water body (Tallis et al. 2011).

Results and Discussion

Results provided by the InVEST water model include the total *water yield* by sub-watersheds, total *amount of nutrients retained* by sub-watersheds, and the *water purification ecosystem service and economic value*. The InVEST model analyzes each pixel to obtain intermediate results. At this scale, these results have no meaning in terms of the hydrological processes. Accordingly, in our analysis, the results were aggregated and presented at the sub-watershed scale.

Water yield

Water is necessary for all life and its availability is strongly influenced by watershed geomorphology, vegetation, and land and water management practices. The water yield model in InVEST links land use and several other key attributes to quantify surface water availability (Mendoza et al. 2011). The model calculates the surface water yield and actual evapotranspiration across the landscape (Tallis et al. 2011). The water yield is defined as all precipitation that does not evaporate or transpire (Mendoza et al. 2011). The water yield for the Lower Suwannee River watershed ranged from 657.8 to 955.2 mm/year, with a mean value of 805.5 mm/year. Sun et al. (2005) calculated the water yield for 38 watersheds, two of them in Florida. Their analysis of the Lower Ochlockonee watershed, which is located close to the Lower Suwannee River watershed, estimated a 637 mm/year water yield.

At the sub-watershed level, the minimum mean water yield value of 657.8 mm/year, corresponded to King Branch sub-watershed located in the northern part of the watershed. This sub-watershed has 90% forest coverage and no FSP properties. The maximum value for water yield was 955.2 mm/year in the Picket Lake Outlet sub-watershed, where only 30% of the area is covered by forestlands and no FSP properties are present.

This variation in the water yield values is expected; greater values correspond to areas where the forest cover is less. Hibbert (1967) mentioned that reduction of forest cover increases water yield. In addition, Swank et al. (2001) identified the increase in water yield as the most obvious and immediate watershed response to forest harvesting due to reduction in total ecosystem evapotranspiration and the increase in runoff[1].

Statistical analysis was performed to understand whether having FSPs in the sub-watersheds affects water yield. We compared this effect for sub-watersheds with and without FSPs. We created two groups of sub-watersheds: group 1 did not have any FSPs (Without FSP - WOFSP); and group 2 had more than 5% (maximum 53%) of their total area occupied by FSPs (With FSP - WIFSP). The results from the t-test showed that water yield was higher in WOFSP, and the difference was statistically significant ($P < 0.05$). This could be due to sub-watersheds without FSPs tending to have less forest cover, thus resulting in a higher water yield.

Nutrient Retention

All plants require certain nutrients for growth, including the algae and rooted plants found in lakes, rivers, and streams. Nutrients required in the greatest amounts include Nitrogen and Phosphorus. Some loading of these nutrients is needed to support normal growth of aquatic plants, an important part of the food chain. However, too much loading of nutrients can result in an overabundance of algal growth with a variety of undesirable impacts (Georgia Department of Natural Resources 1998).

The major sources of nutrient loading in the Suwannee basin are wastewater treatment facilities, urban runoff and storm water, and agricultural runoff. The nutrient retention model provided information about the amount of nutrient (e.g., nitrogen and phosphorus) exported and retained by sub-watersheds. Nitrogen is associated with human inputs such as fertilizers and septic systems. Phosphorus is the key nutrient responsible for over-fertilization of freshwater lakes, ponds, and streams. High phosphorus levels in freshwater bodies are often associated with the use of phosphate-based detergents, lawn and garden fertilizers, improperly

[1]That part of the precipitation that appears in surface streams. It is the same as stream flow unaffected by artificial diversions, storage, or other works of man in or on the stream channels (USGS).

sited and maintained septic systems, leaking sewers, agricultural drainage, pet waste, and urban stormwater runoff (University of Rhode Island 2003).

Nitrogen analysis

Nitrogen loaded in a watershed can take three paths: (1) retained by vegetation, (2) exported to the stream beyond the critical annual load value, and (3) exported to the stream within the critical annual load value. At the watershed level, the total nitrogen loading was 2,142,270 kg. The total amount of nitrogen that was exported to the stream beyond the critical annual load was 54,073.4 kg, and the total amount of nitrogen retained was 842,034 kg. Two and half percent of the total nitrogen loading was exported to the stream and 39% was retained by the vegetation; the remaining 58.5% was exported to the streams but was within the critical annual load. At the sub-watershed level, 28 out of the 63 sub-watersheds analyzed in this study did not export any nitrogen beyond the critical annual load to the stream, as the entire amount was retained by the land cover. If we analyze the percentage of nitrogen retained by the sub-watersheds, the largest amount was found to be retained by Tenmile Hollow sub-watershed, which is located in the northeastern part of the watershed. This sub-watershed retained 52% of the total loaded nitrogen, and its land cover consisted of 39% forest, 41% intensive land use (e.g. crops, pastures, urban areas) and 6% (39 properties) of the sub-watershed area was FSP properties (Appendix 3). Ecosystems with intact natural vegetation tend to be net retainers of both nutrients and sediments, whereas ecosystems used intensively for agricultural production tend to be sources of both nutrients and sediments (Conte et al. 2011).

We tested whether the presence of FSPs in the sub-watersheds affected the Nitrogen retention. We compared two groups of sub-watersheds; one without FSPs (Without FSP-WOFSP), and the other group with more than 5% (maximum 53%) of their total area occupied by FSPs (With FSP-WIFSP). Log of total nitrogen retention was compared between the two groups using a t-test. Total nitrogen exported between the two groups was compared by using Wilcoxon rank sum test. In both cases, we used 5% significance level. The results showed that both nitrogen retention and nitrogen exported were higher on WIFSP, but differences were not statistically significant. The lack of significance could be due to the low number of watersheds with higher total acreage of WIFSPs (n=10) compared to the other group (n=35).

Phosphorus analysis

The total amount of phosphorus loaded in the Lower Suwanee's streams was 271,530 kg. At the watershed level, the total amount of phosphorus that is estimated to reach the stream, beyond the critical annual load, was 8051 kg (3% of the total loading), and the total amount of phosphorus retained was 246,756 kg (91% of the total loading). At the sub-watershed level, 28 out of the analyzed 63 sub-watersheds did not export any phosphorus to the stream beyond the critical annual load, as the entire amount is retained by the land use/cover. In terms of the percentage of phosphorus retained by sub-watersheds, the largest amount was retained by Old Grassy Lake sub-watershed, which is located in the northwestern part of the watershed. This sub-watershed retained 96% of the loaded phosphorus and the land cover consisted 57% forest, 29% intensive land uses and 3% (2 properties) of the area covered by FSP properties (Appendix 3).

We tested whether having FSPs in sub-watersheds affects the percentage of retained phosphorus. Two groups of sub-watersheds were analyzed; one without FSPs (Without FSP-WOFSP), and another consisting of more than 5% (maximum 53%) of the total area occupied by FSPs (With FSP-WIFSP). Log of total phosphorus retention was compared between the two groups using a t-test. Total phosphorus exported between the two groups was compared by using Wilcoxon rank sum test. In both cases, we used 5% significance level was used. The results showed that both phosphorus retention and phosphorus exported were higher in WIFSP, but differences were not statistically significant. The lack of significance could be due to the low number of watersheds with higher total acreage of FSPs (n=10) compared to the other group (n=35).

InVEST Model Assessment

Water Yield Estimates

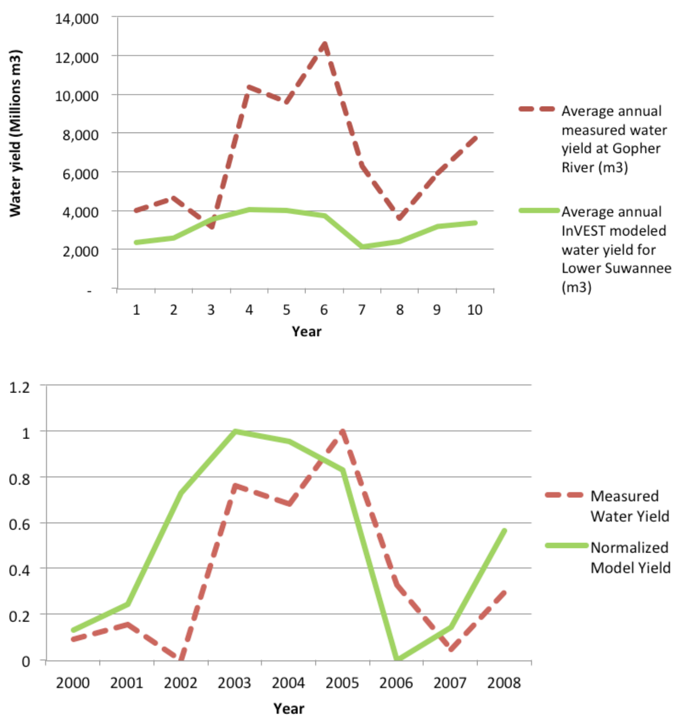
The InVEST model is a tool that can be used to map and value the regulation of ecosystem services related to water using accessible land cover data; however, the model has rarely been used in Florida. The InVEST water yield model is based on a simple water balance that assumes that all rainfall in excess of evaporative loss and plant consumption arrives at the outlet of the watershed (Tallis et al. 2010). The model calculates the annual average water yield as a depth (mm) at the pixel level and then aggregates the data to the sub-watershed and watershed levels. To calculate a volumetric water yield, the depth of each sub-watershed is then multiplied by its area. Therefore, to assess the performance of the InVEST model in the Lower Suwanee Watershed in Florida, we compared model output to measured stream gauge data. Specifically, we used a 10 year average annual water yield and compared it to a 10 year average measured streamflow at a downstream point in the watershed (Tallis et al. 2010). The 10 years of data which were analyzed for the assessment were from 2000 to 2009, a time period modeled by the InVEST analysis (2000 to 2004). Average annual rainfall data from the PRISM Climate Group, Oregon State University (http://prism.oregonstate.edu) were used to generate water yield. Historic streamflow data was from the USGS National Streamflow Information Program, which records stream discharge at eight sites along the lower Suwannee River (Nielsen and Norris, 2007). The farthest site downstream which measures the entire flow of the Suwannee River is at Gopher River near Suwannee FL (Site # 02323592), shown in Figure 2.

Figure 2. Location of stream gauge for water yield calibration

We calculated a metric to assess model performance, specifically a ratio referred to as RSR, which is the root mean squared error (RMSR; measure of the difference between values predicted by a model and the differences between observed values) of the InVEST modeled data divided by the standard deviation of measured streamflow data (Dodge 2003). For streamflow, the RSR ratio should be less than or equal to 70% (Moriasi et al. 2007) and if this condition is not satisfied, a sensitivity analysis will be required to determine how physical parameters of the model affect model output. Sensitivity analyses illustrate the elasticity in the response of the water yield to the change in the input variable. To calibrate the model, analyzed variables can subsequently be adjusted so that modeled data reflects measured data within an RSR ratio less than 70% (Moriasi et al. 2007).

For the time period of 2000 through 2009, the average flow rate through the Suwannee River at Gopher River near Suwannee, FL (Site # 02323592) was 7,636 cubic feet per second (cfs) with a standard deviation of 3,580 cfs. This is equivalent to an average annual volume of 6.82 billion m^3 with a standard deviation of 3.20 billion m^3. The annual average precipitation data for 2000 through 2009 was modeled to compare performance to measured flow data. The measured and annual average volumes are shown in Figure 3a. The average annual water yield results were then compared to the average annual streamflow data to determine the performance of the model. The model estimated an average annual volume of water yield that is approximately half the average measured amount with an RMSR ratio of 141%, which indicates that model calibration is necessary.

To find appropriate variables to calibrate the model output, the water yield was adjusted until a minimum water yield RSR ratio of 72% was obtained (Moriasi et al. 2007); 70% being the RSR at which analyzed variables can be adjusted so that modeled data better reflects measured data. This minimum RSR occurred when water yield was multiplied by 221%. For the sensitivity analysis, soil depth and plant available water content were selected based on the literature and varied by 25% and 50% above and below the original input data to measure the elasticity of the water yield depth output. Further, calibrating the water yield at the watershed scale is more appropriate since the model is designed to account for overall interactions in an annual timeframe. The model does generate results at the subwatershed level, but water yield cannot be calibrated at this scale because the



Figures 3a and *3b.* Modeled water yield (3a) and normalized water yield (3b) relative to measured water yield for the Lower Suwanee River.

stream data has a temporal component that the model will not reflect when using annual averages.

Sensitivity analyses found that plant available water content and soil depth had linear relationships to water yield and since plant available water content is dependent on soil depth, soil depth alone could be the independent variable used for model calibration. However, calibration was not possible given that if water yield was to be increased by 221% to minimize RSR ratio, soil depth would need to be decreased by more than 100%, which is not physically possible. This error is likely a result of the large groundwater component in the Lower Suwannee River and precipitation inputs further upstream. However, the InVEST model does not account for subsurface hydrological processes. Therefore, differences between measured and modeled annual water yield (Figure 3) might be due to this inability to account for subsurface hydrological processes (Tallis et al. 2011) and also differences in the modeled watershed area for the Lower Suwannee and the actual drainage area of the Gopher River gauging station. As a result, the model could not be calibrated to reflect measured water yield, but as seen in Figure 3 it does estimate water yield changes over time from the Lower Suwanee watershed.

Nutrient Retention in the InVEST model

The output of the nutrient retention portion of the InVEST model is the input in the valuation portion of the InVEST model. The model generates the annual average load of nitrogen and phosphorus at the sub-watershed and watershed level. The total amount of nitrogen and phosphorus is divided by the total water yield to obtain an annual average concentration for each nutrient. This concentration is then evaluated as a source for drinking water. If the concentration is above drinking water standards, then the treatment plant would need to upgrade its equipment for Biological Nutrient Removal (BNR; EPA 2007).

In the nutrient retention portion of the model, it was estimated that an average of 54,073.4 kg of total Nitrogen and 8,050.5 kg of total phosphorus are exported to the stream annually. Before the water yield assessment, the model estimated that an average of 3.29 billion m^3 of water flows through the stream annually. This provides an annual average estimate for the concentration of total nitrogen and total phosphorous in the Lower Suwannee River watershed of 0.016 mg/L and 0.002 mg/L, respectively.

Water quality data from the Florida Department of Environmental Protection (FDEP) provides information on stream nutrient concentration for total Nitrogen and phosphorus over a period of time (FDEP 2011). These preliminary results showed that the water quality for nutrients are within drinking water standards (i.e. 1-10 mg/L), thus BNR is not necessary at this threshold. However, nutrient retention output will need to be calibrated to better reflect the measured water quality data in future analyses or a more appropriate hydrologic model used.

Although calibrating the water yield component of the InVEST model would provide better estimates of the nutrient load, modeled nutrient concentrations would not change because nutrient mass would still be proportional, thus resulting in no improvement in nutrient retention estimates. Additionally, normalizing both curves in Figure 3b did result in similar temporal and proportional trends in water yield between measured and modeled water yields. Thus the model is useful to better estimate and understand the hydrological and ecological processes in the modeling domain and associated tradeoffs with changing landuse/covers and management regimes.

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Appendix 1.

Data needs for the InVEST water model (from Tallis et al. 2011)

#	Parameters	Description	Units of measurement	Model Component	Data Source
GIS Layers (raster and shapefiles)					
1	Digital Elevation Models (DEM) - Raster	Elevation value for each cell.	meters	Nutrient retention	U.S. Geological Survey (USGS)
2	Soil depth - Raster	Minimum of depth to bedrock and typical water table depth.	millimeters	Water yield	Soil Survey Staff, Natural Resources Conservation Service, USDA. U.S. General Soil Map-STATSGO2
3	Precipitation - Raster	A non-zero value for average annual precipitation for each cell.	millimeters	Water yield	PRISM Climate Group (formerly SCAS) - Oregon State University
4	Plant Available Water Content (PAWC)- Raster	It is the fraction of water that can be stored in the soil profile that is available for plants' use.	No unit	Water yield	Soil Survey Staff, Natural Resources Conservation Service, USDA. U.S. General Soil Map-STATSGO2
5	Average Annual Potential Evapotranspiration - Raster	Potential evapotranspiration is the potential loss of water from soil by both evaporation from the soil and transpiration by healthy Alfalfa (or grass) if sufficient water is available.	millimeters	Water yield	U. S. Geological Survey's Florida Integrated Science Center
6	Landcover (LC - Raster	A LC code for each cell		Water yield Nutrient Retention	Florida Fish and Wildlife Conservation Commission (2003)
7	Watershed - Shapefile	This is a layer of watersheds such that each watershed contributes to a point of interest where water quality will be analyzed.		Water yield Nutrient Retention	U. S. Geological Survey
8	Sub-watershed - Shapefile	This is a layer of sub-watersheds, contained within the Watersheds (described above) which contribute to the points of interest where water quality will be analyzed.		Water yield Nutrient Retention	U. S. Geological Survey
Tabular data					
9	*Model Coefficients Table*				

Data needs for the InVEST water model (from Tallis et al. 2011) *continued*

#	Parameters	Description	Units of measurement	Model Component	Data Source
9.a	Root depth (per landcover type)	Maximum root depth for vegetated land use classes	millimeters	Water yield Nutrient Retention	Heyward 1933; Canadell et al. 1996; Bares 2002; Hwang et al. 2009; Tallis et al. 2011;
9.b	Evapotranspiration coefficient (etk; per landcover type)			Water yield Nutrient Retention	Tallis et al. 2011
9.c	Nutrient loading (load_n and load_p; per land cover type)	Defined as the amount of nutrient (e.g. nitrogen or phosphorus) delivered annually to a water body from a specific area (Wickham J. D. et al. 2003).	Kg/ha/yr	Nutrient Retention	Schuman et al. 1973; Harms et al. 1974; Kilmer et al. 1974; Correll et al. 1977; Krebs and Golley 1977; Henderson et a1. 1977; Menzel et al. 1978; Rast and Lee 1978; Chichester et al. 1979; Olness et al. 1980; Reckhow et al. 1980; Loehr et al. 1989; Dodd et al. 1992; Lin 2004
9.d	Removal efficiency (eff_n, eff_p; per land cover type)	Removal efficiency refers to the capacity of vegetation to retain nutrient	%	Nutrient Retention	Doyle et al. 1977; Boyt et al. 1977; Tilton and Kadlec 1979; Yonika and Lowry 1979; Young et al. 1980; Nichols 1983; Peterjohn and Correll 1984; Cooper and Gilliam 1987; Dillaha et al. 1989; Osborne and Kovacic 1993
10	Threshold Flow Accumulation Value (per watershed)	Defined by the number of upstream cells that must flow into a cell before it's considered part of a stream.	Number of cells	Nutrient Retention	ArcHydro/Stream definition
11	Zhang Constant/ seasonality factor (per watershed)	Corresponds to the seasonal distribution of precipitation.		Water yield	Tallis et al. 2011

Data needs for the InVEST water model (from Tallis et al. 2011) *continued*

#	Parameters	Description	Units of measurement	Model Component	Data Source
12	Water Purification Valuation Table				
12.a	Calibration data (per watershed)	Calibration data is needed for ensuring that the Tier 1Water Purification: Nutrient Retention model results match well with reality		Valuation	Tallis et al. 2011
12.b	Critical Annual Load (per watershed)	Total critical annual nutrient loading allowed for the nutrient of interest (e.g. Nitrogen and Phosphorus).	Kg/year	Nutrient retention Valuation	Florida Department Of Environmental Protection (FDEP)/ Division of Water Resource Management/ Bureau of Watershed Management 2008; Trepanier et al. 2002
12.c	Marginal pollutant removal cost (per watershed)	Annual cost of nutrient removal treatment.	$/kg removed		
12.d	Time_span (years; per watershed)	Number of years for which net present value will be calculated.	years		
12.e	Discount rate (%; per watershed)		%		

Appendix 2.

Water Yield Model Parameter-Methods

1. *Digital Elevation Model (DEM):* The DEM raster was downloaded from the Florida Geographic Data Library. This is State-level data, with a resolution of 90 meters and a scale of 1:250,000. The source of the data is the US Geological Survey. For the InVEST Water Purification model, using a well-defined DEM is critical; the DEM should not have missing data or circular flow paths and should correctly represent the surface water flow patterns over the area of interest (Tallis et al. 2011). The ESRI ArcHydro tool was used to prepare the DEM data for use through a procedure recommended in the InVEST software user guide. The procedure suggests burning the existing stream lines in the DEM raster, identifying and filling sinks, and generating the flow accumulation using the corrected DEM. Both generated and existing stream network must match before the prepared (corrected) DEM can be used in the analysis.

2. *Soil depth*: The source of the data was the Natural Resources Conservation Service-NRCS, USDA. U.S. General Soil Map-STATSGO2. The Soil Data Viewer[2] tool was used to generate the soil thematic maps. The tool generates spatial information directly in a vector format that is converted to raster format for use in the model. The maximum soil depth and water table depth were generated using this tool and the final input is the combination of these two data sets.

3. *Precipitation:* Annual summary of original ASCII data for the years 2000-2004, obtained from PRISM Climate Group (formerly SCAS) - Oregon State University was converted to a raster format and used in the analysis.

4. *Average Annual Potential Evapotranspiration (PET):* The original data (organized as ASCII 2km grid) was obtained from U. S. Geological Survey's Florida Integrated Science Center and converted to raster format. The PET daily data is by county. The data was downloaded and converted to a 2km resolution raster layer. Preparing the PET data involved the following steps: (a) getting the annual data for each cell (original data is daily) for the years 2000-2004, (b) converting tabular data to spatial data using the latitude and longitude coordinates of each data point, and (c) converting point data to a raster format using interpolation methods. This process was applied for the counties within the Lower Suwannee River watershed. The annual raster layers were averaged to get the average annual potential evaporation layer.

5. *Plant Available Water Content:* The InVEST model requires a GIS raster dataset with a plant available water content value for each cell. The source of the data is the General Soil Map-STATSGO2 obtained from the Natural Resources Conservation Service-NRCS, USDA. U.S. The Soil Data Viewer tool was used to get the vector data set, which was converted to raster format and used in the model.

6. *Root depth*: We used root depth values for vegetated land cover types, except for wetlands and grasslands species, listed in a review conducted by Canadell et al. (1996). In this publication, the species were grouped by biomes (from boreal forest to tropical forest, etc.) and by major functional groups such as tree, shrubs, herbaceous plants and crops. To assign maximum root depth values to each land use/land cover type of the Lower Suwannee Watershed, the followed steps were applied: (a) species corresponding to each land use and land cover type were noted as the values were assigned considering dominant specie(s) and/or the species with deepest rooting depth, in each land use/land cover type. When the species of interest was not available in the literature, we used the average value of the most relevant biome, based on the fact that rooting depths are consistent among similar biomes and plant species. (b) For the non-vegetative land use/land cover classes such as, urban, extractive and Sand/Beach, a value of 1 was assigned as suggested by Tallis et al. (2011).

7. *Nutrient loading:* Nutrient loading value for each land use/land cover type was obtained from the manual and compilation of export coefficients by Reckhow et al. (1980) and the publication prepared by Lin (2004) through the Wetlands Regulatory Assistance Program (WRAP). The values reported were based

[2] Soil Data Viewer is a tool built as an extension to ArcMap that allows a user to create soil-based thematic maps.

on land use type and/or vegetation similar to those in the Lower Suwannee watershed. When there was no similarity, we considered the most general land use type.

8. *Removal efficiency:* Removal efficiency values for the land use/land cover types (Gilbert and Stys, 2003) were assigned based on the species within each type. The values used for each vegetated land cover type are from Nichols (1983) and Boyt et al. (1977) for wetlands, and from Osborne and Kovacic (1993) for upland forested and grass land cover types. For our analysis, only values for P were available. For non-vegetation land cover types such as urban, extractive and sand/beach, a value of 0 was assigned as suggested by Tallis et al. (2011).

9. *Threshold Flow Accumulation Value*: Using the Stream definition in ESRI ArcHydro tool the threshold accumulation value was obtained.

10. *Zhang Constant:* The Zhang constant is the seasonality factor and is used to characterize the seasonality of precipitation in the area (Tallis et al. 2011). The Lower Suwannee River watershed is located in a subtropical ecoregion, where most rainfall occurs during the summer months similar to tropical ecoregions. According to Tallis et al (2011), the value for tropical watersheds was 4; hence this value was used.

11. *Critical Annual Load*: The target Total Maximum Daily Load (TMDL) for the Middle and Lower Suwannee River Water shed established by the Florida Department of Environmental Protection (FDEP) was an average monthly concentration of 0.35 mg/L of Nitrate. To achieve this TMDL the 2005 total annual nutrient load was reduced by 51%. Accordingly, the critical annual load for the water model was produced by taking 51% of the 2005 recorded nutrient load of 6,197,855 kg N/year. According to Trepanier et al. (2002), the safe Nitrogen to Phosphorus ratio is about 1 to 10. The critical load derived from the FDEP's Nitrate TMDL was divided by 10 to approximate the critical load for phosphorus.

Appendix 3.

Nitrogen and Phosphorus retention by sub-watershed

ID	Sub-watershed name	Area (ha)	% FSP	% No FSP	# FSP	% of forest	% of Intensive LU	Water yield (mm/ year)	% N exported	% N retained	% P exported	% P retained
1	Barnett Creek	896.91	0	100.0	0	2.54	0.00	941.00	0.00	0.75	0.00	7.05
2	Tenmile Hollow	31,615.89	6.1	93.9	39	39.37	41.22	793.70	4.10	51.79	5.37	92.09
3	Patterson Sink	10,499.31	2.9	97.1	3	61.17	7.08	786.83	1.33	22.92	1.36	91.58
4	Springhead Creek	1,485.04	0	100.0	0	67.19	6.28	733.74	14.24	27.05	18.53	75.81
5	Ne San Pedro Bay	3,999.04	0	100.0	0	83.15	0.22	729.72	5.61	6.76	7.28	85.90
6	Blacksnake Creek	1,108.62	0	100.0	0	60.68	2.79	767.65	3.16	22.22	2.93	86.87
7	Williams Waterhole Dr	726.78	0	100.0	0	47.60	4.95	823.74	8.60	26.96	8.46	77.25
8	Lafayette Mill Creek	1,250.34	0	100.0	0	63.47	10.50	746.11	10.44	27.71	14.95	73.63
9	Peacock Slough	10,243.03	0	100.0	0	36.57	49.68	727.85	2.40	34.94	6.27	90.96
10	Grassy Pond	1,610.54	0	100.0	0	67.80	4.40	743.95	0.16	21.10	0.14	90.51
11	Little River	14,424.14	1.0	99.0	6	38.41	43.40	762.39	2.72	39.06	3.16	91.53
12	Fourmile Creek	2,267.51	1.0	99.0	2	81.81	3.65	699.39	3.87	12.93	5.78	83.47
13	Bethlehem Church	4,317.13	5.4	94.6	6	45.28	38.54	732.77	8.95	32.25	8.83	79.31
14	Crab Creek	1,176.87	14.5	85.5	2	80.23	7.12	706.22	0.00	14.05	0.00	85.56
15	West Crab Creek	674.03	12.8	87.2	2	94.08	0.09	667.90	0.00	2.53	0.00	92.16
16	East San Pedro Bay	5,061.37	0.9	99.1	3	61.94	11.71	762.95	1.32	23.93	3.05	93.43
17	Blue Lake Slough	17,399.00	8.1	91.9	8	34.23	45.75	776.39	1.52	48.18	1.73	95.74
18	South Wellborn	1,019.36	19.2	80.8	2	52.06	34.64	721.71	0.00	31.10	0.00	84.99
19	King Branch	253.28	0	100.0	0	91.86	3.46	657.84	0.00	0.25	0.00	54.86
20	Brewer Lake	1,188.94	3.8	96.2	2	49.82	28.75	757.55	1.96	37.79	1.85	88.90
21	South Suwannee Slough	17,138.54	9.0	91.0	13	33.50	39.30	802.30	1.48	41.33	1.52	91.10

Nitrogen and Phosphorus retention by sub-watershed *continued*

ID	Sub-watershed name	Area (ha)	% FSP	% No FSP	# FSP	% of forest	% of Intensive LU	Water yield (mm/year)	% N exported	% N retained	% P exported	% P retained
22	Murray Road	1,322.94	0	100.0	0	31.50	53.73	805.14	0.00	42.57	0.00	89.48
23	Rocky Hill Tower	600.70	2.3	97.7	1	53.50	24.48	739.13	0.00	26.85	0.00	78.90
24	Thomas Spring	716.12	0	100.0	0	42.23	28.26	794.96	2.99	29.29	3.52	80.70
25	Allen Mill Pond Drain	868.88	0	100.0	0	41.77	35.49	751.16	0.00	27.17	0.00	77.43
26	Lafayette Blue Spring	6,274.86	1.8	98.2	3	52.71	28.89	751.87	0.01	30.51	0.01	91.84
27	Irving Slough	1,786.16	0.1	99.9	1	49.70	30.04	744.11	0.06	27.48	0.11	91.57
28	Old Grassy Lake	5,954.06	2.6	97.4	2	57.35	29.31	771.54	0.00	44.26	0.00	96.52
29	Elliott Cemetery	1,314.11	0	100.0	0	38.06	41.64	748.00	0.07	25.64	0.07	87.19
30	Owens Spring	2,383.29	4.4	95.6	2	54.45	29.95	745.71	0.00	28.71	0.00	93.25
31	Picket Lake Outlet	2,606.19	0	100.0	1	29.07	7.30	955.19	0.00	21.65	0.00	92.77
32	James Lake	1,224.77	0	100.0	0	35.75	39.92	788.01	6.36	32.45	5.57	90.09
33	Wampee Ponds	7,115.48	0	100.0	0	32.46	3.49	942.08	3.17	17.54	2.24	92.36
34	Grady	918.47	0	100.0	0	70.90	8.62	744.19	1.71	17.16	1.37	77.58
35	Mallory Swamp	6,251.56	0.3	99.7	1	35.15	3.95	935.65	0.00	16.27	0.00	93.34
36	Bethel Church	1,933.95	0	100.0	0	49.19	24.47	775.90	0.00	30.27	0.00	89.29
37	Se Mallory Swamp	4,178.78	0	100.0	0	35.86	7.58	911.08	0.00	20.72	0.00	92.88
38	Sevenmile Lake Outlet	1,803.09	0	100.0	0	32.16	34.47	773.33	0.00	40.80	0.00	94.94
39	Cow Pond Outlet	3,236.66	0	100.0	0	48.59	11.98	836.11	0.00	23.50	0.00	92.16
40	Beason Prairie Drain	7,862.08	0	100.0	0	67.13	4.16	809.44	0.00	12.71	0.00	91.90
41	Rock Bluff Spring	1,550.36	1.6	98.4	2	19.91	60.08	784.99	3.92	42.85	3.01	86.75
42	Log Landing Slough	2,489.12	3.8	96.2	6	23.41	46.14	829.02	4.22	50.30	4.65	88.79
43	Fletcher	1,189.17	0	100.0	0	27.07	50.89	803.20	0.00	37.61	0.00	85.49

Nitrogen and Phosphorus retention by sub-watershed *continued*

ID	Sub-watershed name	Area (ha)	% FSP	% No FSP	# FSP	% of forest	% of Intensive LU	Water yield (mm/ year)	% N exported	% N retained	% P exported	% P retained
44	Hart/Sun Spgs Slough	10,108.40	3.2	96.8	6	30.33	50.07	802.19	4.17	38.63	4.12	88.98
45	Old Town Hammock Drain	5,490.37	0	100.0	0	61.05	11.16	859.78	8.23	37.63	10.10	84.70
46	East Hammock	5,047.52	0	100.0	0	46.66	30.22	884.12	0.00	51.60	0.00	85.82
47	Jennings Lake Sink	2,294.96	51.2	48.8	1	65.13	13.66	763.22	0.00	16.49	0.00	82.86
48	Otter Springs	6,827.49	26.9	73.1	5	42.36	44.91	773.60	2.86	36.80	3.53	91.36
49	Gilchrist/Levy Slough	12,225.10	3.3	96.7	12	33.24	55.77	815.65	0.35	46.86	0.44	93.27
50	South Old Town	5,441.11	0	100.0	0	39.90	26.69	907.07	0.00	47.31	0.00	90.28
51	Waccasassa Slough	6,429.11	0	100.0	0	30.05	56.36	830.66	0.61	42.45	0.68	91.79
52	Pine Landing	1,161.37	0	100.0	0	47.78	6.54	897.58	0.00	18.77	0.00	89.19
53	Manatee Springs Slough	10,088.23	0	100.0	0	40.65	46.51	851.58	0.17	49.44	0.26	95.77
54	Dixie Alligator Lake	1,916.59	0	100.0	0	67.08	2.37	835.87	0.00	11.03	0.00	78.69
55	Long Pond	11,903.99	0.5	99.5	2	34.17	44.52	874.87	2.28	40.58	3.06	92.63
56	East Long Pond	4,777.46	29.1	70.9	1	43.01	35.09	869.71	1.61	36.77	0.84	93.39
57	Yellow Jacket Slough	824.05	0	100.0	0	72.33	2.29	818.82	0.00	22.74	0.00	90.27
58	Section 17 Drain	1,071.76	0	100.0	0	75.51	1.37	797.47	0.00	17.18	0.00	83.46
59	Turkey Island	1,716.66	0	100.0	0	66.81	1.47	868.74	0.00	19.76	0.00	76.62
60	Week Creek	679.48	0	100.0	0	70.18	2.48	853.28	0.00	15.24	0.00	63.57
61	Sandfly Creek	9,311.30	0	100.0	0	69.63	18.33	797.10	0.00	17.48	0.00	88.80
62	Gopher River	636.93	0	100.0	0	74.34	0.00	752.91	6.31	10.49	5.82	80.65
63	Lower Suwannee River	118,937.66	2.0	98.0	67	45.54	29.81	802.26	3.51	39.48	3.94	90.31

Economic Value of Water Resource Protection and Forest Conservation

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Introduction

Nutrient pollution from anthropogenic sources is a leading cause of water impairment in the United States (US EPA 2002). Forest ecosystems are thought to be an effective and sustainable means of buffering aquatic ecosystems against nutrient pollution (Phillips 1989), thereby functioning as a source of clean water supply (de Groot et al. 2002). To maintain the water-related ecosystem services provided by forest lands, environmental polices often propose the use of various types of forest conservation programs. In the absence of the 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 (CV) survey methods. These survey methods are used to elicit the respondent's willingness-to-pay (WTP) for benefits associated with protecting water quality.

The CV approach relies on the ability of the general public to fully consider actual or expected environmental changes, translate those changes into a feeling of gain or loss with respect to specific environmental goods and services, and to directly or indirectly communicate the magnitude of the gain or loss in monetary terms. Therefore, WTP estimates from CV studies are sensitive to baselines used to assess the value of changes in environmental quality (Venkatachalam 2006; Shogren et al. 1994). For example, we expect WTP to improve water quality of a lake from 'poor' to 'good' to be different than WTP to prevent water quality of that lake from falling from 'good' to 'poor'.

The vast majority of CV studies that focus on forest conservation report WTP to *improve* water bodies that are heavily polluted (Thurston et al. 2009). Although Florida has a high number of waters that are "impaired" by EPA 303(d) water quality criteria (US EPA 2012), estimates of WTP to improve water quality of heavily polluted waters are not expected to provide reliable estimates for forest-based conservation in Florida. To assess the economic value of the Florida Forest Stewardship Program, we instead rely on estimates of WTP to *protect* water quality.

The CV studies that focus on forest conservation to protect well-conserved, or relatively unpolluted, aquatic systems are proportionally few when compared to the number of studies that focus on WTP to improve water quality in already-polluted aquatic systems (Thurston et al. 2009). So, this study will focus on the values associated with the protection of well-conserved aquatic systems via forest conservation. Quantifying these values provides an important baseline for understanding the potential economic benefits of preventing nutrient pollution and support for various kinds of water resource protection and forest conservation programs that help drive cost-effective conservation and land use policies.

Specifically, this study presents the results of a meta-analysis of WTP values for programs, including those related to forest conservation, that protect water quality in well conserved aquatic systems. The study also explains how geographical region, scope-of-program (specific site, watershed, statewide), type of resource (lake or stream) and type of policy or conservation tool (i.e. conservation easement, landowner incentives) influence WTP. First, we summarize the literature on WTP for protection of well-conserved water bodies related to forestland. Then, we present conceptual and econometric models of factors driving WTP for programs that use forestland to protect water quality. Finally, a meta-analytic approach is applied to parameterize the econometric models, and the results are reported and discussed. Since the Forest Stewardship Program (FSP) promotes forest conservation, thereby protecting water quality, a WTP analysis of forest conservation and water quality protection programs will be used as a proxy for FSPs. The results from this study should therefore be useful to assess the value of the FSP for protecting water quality.

Conceptual Approach

Benefits of Forest Conservation

Forests provide key ecosystem functions that affect water supply and quality such as filtering, retention and storage of water in streams, lakes and aquifers. The filtering function, or retention of excess nutrients, is mainly performed by the vegetation cover and soil biota (de Groot et al. 2002). These functions buffer aquatic ecosystems against nutrient stressors, such as nitrogen, and provide clean water as a service benefiting humans. Excess nutrients in aquatic systems contribute to the eutrophication of surface waters and a reduction in ecosystem service benefits such as fishing, swimming and aesthetics. The benefits related to these ecosystem services are often categorized as use, option, or nonuse values (Just et al. 2004). Use values include direct benefits of improved recreational experiences and aesthetic benefits received directly by the consumer from, for example, maintaining water quality in a lake (Just et al. 2004). Option value refers the potential future value of the future service that may not be yet known. Indirect, nonuse values are usually categorized as existence or bequest values, which are defined as the value derived from knowing that the resource is maintained and the value of knowing the resource will be available for future generations to enjoy (Just et al. 2004). The decision to conserve forestland is an important step in reducing stress on aquatic ecosystems so that they continue to provide clean water services and maintain the benefits associated with good water quality (Wainger and Mazzotta 2011).

Program Approach to Protecting Water Quality

Environmental policies that protect water quality will often use forest conservation to achieve the proposed benefit outcomes. Conservation programs use a variety of mechanisms, including land acquisition, conservation easements, landowner incentives and assistance programs upon implementation. Some forest conservation CV studies focus exclusively on the benefits of protecting water quality (Shrestha and Alavalapati 2004; Cho et al. 2005; Condon 2004) while other studies present water quality protection as only one of the benefits of forest conservation along with preservation of green space, natural areas, wetlands and wildlife habitat and environmental education (Carman et al. 1992; Blaine et al. 2003; Blaine and Litchkoppler 2004; Blaine and Smith 2006; Cooksey and Theodore 1995). Most frequently CV studies that measure WTP to protect water quality propose the use of nonspecific "environmental programs" (Petrolia et al. 2011; Holmes et al. 2004; Giraud et al. 2001; Mannestso et al. 1991; Sanders et al. 1990; Whitehead 1990; Aiken 1985; Greenley et al. 1981). Under certain circumstances the primary purpose of a CV study may not be to inform policy with measures of welfare but to test differences in methodological approaches, such as double-bounded versus single-bounded dichotomous choice or the effect of distance on WTP (Hanemann et al. 1991; Sutherland and Walsh 1985). While the valuation literature frequently discusses the benefits of resource protection, economists frequently assess WTP for land preservation independent of detailed information on the policy process, or with vague references to the tools used to implement the proposed conservation program (Johnston, 2007).

Meta-Analysis and Benefit Transfer Methods

Meta-analysis method

Meta-analysis is a general term for any methodology that summarizes results from several studies. We conducted a meta-analysis of WTP studies by gathering WTP estimates from several studies that then served as the dependent variable in regression analysis, while the characteristics of the individual studies served as the independent variables. The parameterized model can then be used to predict WTP across locations and time periods while controlling for differences in study methodologies. In general the model can be specified as

$$y_i = \alpha_{0i} + \beta_{1i}x_{1i} + \ldots\ \beta_{ki}x_{ki} + \varepsilon$$

where y_i is the WTP estimate in study i and β_0 α_{0i} is the intercept, which acts as a constant term in the model; $\beta_{1i} \ldots \beta_{ki}$ are the parameters; $x_{ij} \ldots x_{ik} x_{1i} \ldots x_{ki}$ are the variables that account for different characteristics of the study i, such as site characteristics and study methodology; and ε ε accounts for between-study variation. It is important to include variables related to study methodologies when conducting a meta-analysis because of their influence on the elicited WTP values (Walsh et al. 1992; Loomis and White 1996; Brouwer and Spaninks 1999; Rosenberger and Loomis 2000). In the field of environmental valuation, meta-analysis has focused on a range of environmental issues, including the economic benefits associated with protecting endangered species (Loomis and White 1996), outdoor recreation (Walsh et al. 1992; Rosenburger and Loomis 2000; Shrestha and Loomis 2003), wetlands (Brower and Spaninks1999; Woodward and Wui 2001) and water quality improvements (Johnston et al. 2005; Williamson et al. 2009). To date, however, there have been no meta-analyses on WTP values associated with the protection or preservation of well-conserved aquatic systems.

The meta-analytical model can also be used to explain the variation in benefit estimates (McKean and Walsh, 1986). In an ordinary demand function of a particular benefit, such as the benefits associated with clean lakes and rivers, the dependent variable (WTP) is explained by the "quantity" of the benefit demanded. Often the quantity demanded is quantified based on a change in benefits. For example, in polluted aquatic systems the change in demand is based on the level of water quality improvement (often quantified using a scale such as the water quality ladder proposed by Resources for the Future; Carson and Mitchell 1993). Existing CV studies conducted on relatively unpolluted aquatic systems propose to measure the change in demand for the associated services based on hypothetical scenarios such as the potential increase in pollution for due to population growth (Eisen-Hecht and Kramer 2002), an increase in mining activity (Sutherland and Walsh 1985; Greenley et al. 1981) or the quantity of water that would be protected based on the temporal or geographical scale of the proposed water quality protection program (Sanders et al. 1990; Holmes et al. 2004; Condon 2004).

The list of independent variables in a regression model that influence demand includes site characteristics, individual attitudes and preferences, study and methodology attributes, and socioeconomic characteristics such as income. *Site characteristics* often include (1) a description of the resource (i.e. lake, wetland, river, saline, or freshwater; Brouwer 1999; Woodward and Wui 2001; Johnston et al. 2005); (2) the geographic scope or scale of the protection program (e.g. single river or lake, all the resources within a drainage basin, or resources located statewide; Brouwer 1999; Williamson et al. 2009; Johnston et al. 2005); and (3) the region or state in the US where the resource is located (Walsh et al. 1992; Rosenberg and Loomis 2000; Johnston et al. 2005). While meta-analyses often include the above site characteristics, we found no meta-analyses estimating WTP for changes in water quality that include information about what conservation tools, such as land acquisition or assistance programs, would be used to implement the proposed changes. As stated earlier, many CV studies often overlook the possibility that policy process or tools used to implement the program itself may influence WTP (Johnston and Duke 2007), although we suspect an aversion by some people to certain payments and processes (e.g., taxes). Therefore, a better understanding is needed on the existence of preference patterns for implementing water quality protection and forest conservation programs and their relevance to WTP for changes in water quality.

Study attributes used in a meta-analysis characterize features like year in which a study was conducted, elicitation format (e.g., open-ended CV), and study response rates. The year in which the survey is conducted is often negatively correlated with WTP and it is frequently explained as a reduction of survey bias over time that decreases overestimation of WTP (Johnston et al. 2005; Woodward and Wui 2001; Loomis and White 1996; Arrow et al. 1993). Different forms of stated preference or CV survey methodology can have a positive or negative effect on WTP. Studies comparing open-ended to dichotomous choice questions have shown that values from the dichotomous choice method equal or exceed those of the open-ended (Brower and Spaninks 1999; Loomis and White 1996; Balistreri et al. 2001). However, other stated preference methods such as iterative bidding and payment cards were found to elicit values that were higher compared to dichotomous choice (Boyle and Bishop 1988). Survey response rate is often used as a proxy for variance or a measure of heteroscedasticity among observations (Nelson and Kennedy 2008), which can be used to address estimation concerns and therefore provide better estimates of WTP (Johnston et al. 2005; Brouwer and Spaninks 1999; Loomis and White 1996).

In turn, *socioeconomic characteristics* of survey respondents such as sex, race, age and income have been found to influence WTP (Williamson et al. 2009). Information about these characteristics are not available in all CV studies; however, information about income can be gathered from sources outside of the original study (e.g., US Census data) and can be included in a meta-analysis (Shrestha and Loomis 2003; Williamson et al. 2009). Income is expected to be positively correlated with WTP. Good water quality is generally considered a normal or necessary good, and according to income elasticity of demand theory, as income increases, demand for normal goods also increases (Just et al. 2004).

Benefit transfer method

A benefit transfer (BT) is a valuation method that utilizes existing resource value estimates to make judgments about the value of resources at a different or new site, also known as the policy site. This is often done when valuation data at the policy site is not available or when it is infeasible to conduct economic valuation exercises due to the time or funding constraints. Benefit transfer can be done in two ways: (1) by direct transfer of unit-value estimates, and (2) by the transfer of a benefit function (Navrud and Bergland 2001). A simple *unit-value transfer* assumes that the study site characteristics and the people at the study site (in terms of income, education, religion, and ethnic group) are the same or similar to those at the policy site. Therefore, mean money value estimates, such as WTP, are directly transferred from the study site to the policy site. This approach is infeasible when no appropriate valuation studies exist that are similar enough to the policy site. A *transfer of the benefit function* can be done by conducting a meta-analysis of previous studies that are somewhat similar to the policy site. Mean values are generated using the study site characteristics (biophysical and socioeconomic), which are then adjusted and applied to the policy sites. For example, Williamson et al. (2009) used four different WTP studies on acid mine drainage to create a model to predict changes in WTP as water quality improved from severely polluted to unpolluted in a similar watershed. Johnston et al. (2005) conducted a meta-analysis of 34 WTP studies to measure differences in model specification in predicting changes in WTP for increasing levels of water quality improvements for fish and shellfish.

In turn, Johnston and Besedin (2009) describe the general form of a benefits transfer based on a meta-analysis as

$$y = a + w_1 b_1 x_1 + \dots + w_k b_k x_k$$

where y is the predicted WTP at the policy site, a is the intercept from the meta-analysis model, $b_1 \dots b_k$ are the coefficients for the variables, $x_1 \dots x_k$, obtained from the meta-analysis model and $w_1 \dots w_k$, refers to the weight assigned to each variable for the purpose of adjusting the model to capture the desired characteristics of the policy site. An important limitation of the benefit function transfer method is that it is only useful if all of the explanatory variables of interest are included (and their values are known) for the study sites for which the coefficients are estimated. For both methods it is also essential that study sites are substantially similar to policy sites and that other unaccounted for drivers of WTP are similar at both the study and the policy sites.

Data collection

Data for this analysis were drawn from the economics literature and include CV study estimates of WTP for programs that maintain or protect "in-stream" water quality from potential degradation. Criteria for inclusion in the analysis were: (1) the water resource being valued was "well conserved" or categorized as fair or good as defined by the levels of use support by the US EPA Report to Congress 1994; (2) the study estimated annual household or individual WTP; (3) the study was conducted in the United States; (4) the type of resource being protected was fresh surface water and; (5) study methods were CV or comparable survey methods. The resulting metadata comprised 43 observations from 18 unique studies drawn from both scientific journals and the gray literature conducted between 1976 and 2010 (Appendix 1). Multiple WTP estimates from single studies were available due to in-study variation in such factors as elicitation methods and statistical analyses.

Variables for Study, Socioeconomic and Site Characteristics

We collected the most commonly reported study characteristics, including type of survey methodology, year indexed, and response rate. Stated preference survey methodologies included open-ended survey, payment card, dichotomous choice, iterative bidding, and attribute choice experiment (Appendix 1). Most of the surveys were conducted by mail; however, one study was conducted online and one study used on-site interviews. The year the survey was conducted was always reported and ranged from 1976 to 2010. Sample size along with response rate was also reported in every study and ranged from 90 to 3,000 respondents with a response rate ranging from 19% to 100%. Standard error was infrequently reported, leaving limited options for including a weighting variable representing study quality; instead response rate was used as a proxy for study variance or a measure of heteroscedasticity among observations (Nelson and Kennedy 2008).

Variables for socio-economic and site characteristics include annual household income, geographical region or state, type of aquatic resource, scope of the water quality protection program and the conservation tool used to implement the program. About half of the studies in this analysis reported socio-economic data about the respondents such as the respondent's ethnicity, gender or age but more often only median annual household income were reported (Appendix 1). Additional household income at the county level was found through the US Census Bureau (http://factfinder.census.gov, accessed November 1, 2011) using normalized to 2010 US dollars income. Many of the studies were conducted in the western US; however, six studies were conducted in southeastern states and four in northeastern and midwestern states. The type of resources valued included streams, rivers, lakes, wetlands and all surface water resources combined. Most of the studies focused on valuing streams and rivers; however, six studies valued wetlands and four valued all water resources combined; only one study elicited values associated with lakes. The spatial scale of the proposed water protection program ranged widely. Some programs focused on protecting a resource at a single site, such as a single lake or wetland, or addressed the protection of water resources statewide. Most programs focused on protecting river watersheds and wetlands distributed throughout a drainage basin (Appendix 1).

Variables for Program/Policy Characteristics

Coding for the policy process or the attributes of the water quality protection program included land acquisition, conservation easements, as well as landowner incentive and assistance programs where the intended purpose would be to preserve the ecosystem structure and function of forested lands, mixed land use areas, riparian areas, wetlands and other important lands to protect in-stream water quality. Of the eighteen studies in our meta-analysis, six programs proposed land acquisition or easement strategies and one study proposed a cost-share program for land owners. Ten studies proposed the use of non-specific "environmental" programs and did not describe to the respondent how water quality protection objectives would be achieved which may have required the respondent to make assumptions about how the proposed program would affect their preferences and level of utility (Appendix 1).

Empirical model and analyses

Using our meta-analysis, we investigated significant drivers of WTP, including the conservation tools used to implement the program, as well as the outcomes of a water quality protection program. Independent variables were selected based on the previous studies that employed water quality meta-analysis method (Johnston et al. 2005; Heberlein et al. 2005; Loomis and White 1996), as well as the information available for the study sites (Appendix 2). Our regression model included variable categories, where levels within each category are compared to reference variables. Initial regression models found that some variable levels could be collapsed due to a lack of significant difference. Appendix 2 describes the final variable levels used in the model

$$\ln WTP = \alpha_0 + \beta_{1\ Method} + \beta_{2\ Year} + \beta_{3\ Weighting} + \beta_{4\ Income} + \beta_{5\ Region} + \beta_{6\ Resource} + \beta_{7\ Scope} + \beta_{8\ Program} + \varepsilon$$

where lnWTP is the natural log of annual individual WTP or the effect size, α_0 is intercept or the estimated overall effect size, $\beta_1 \ldots \beta_n$ are coefficients representing the study and methodology attributes (survey methodology, year index, response coefficient), socio-economic characteristics (annual household income), and site characteristics (region, resource, scope, program) of each study, and ε specifies the between-study variation (Appendix 2).

The metadata were analyzed using a stepwise hierarchical multiple regression model. Following Johnston et al. (2005) and Loomis and White (1996), we used a semi-log form where the dependent variable is the natural log of WTP and independent variables are linear. Variable levels were hierarchically compared against a corresponding reference variable to calculate a regression coefficient (Table 1). An additional variable calculated as one divided by the number of observations from each study, was used as a weighting variable for each observation to reduce within-study autocorrelation (Nelson and Kennedy 2008). Assumptions of normality were evaluated with a Shapiro-Wilk test ($p<0.10$) and multi-collinearity was assessed with eigenvalues of centered correlations, and no significant problems were observed.

Model Results and Discussion

Regression results show numerous statistically significant patterns that influence WTP for protecting water quality, and the statistical fit of the estimated equation was very good. Coefficients of all variables were significant, at either $p<0.05$ and the model had an adjusted R^2 of 0.98 indicating that 98% of the variation in WTP is explained by modeled variables (Table 3). Implications for benefit transfer are discussed below.

Systematic Variation in Study Variables

For variable category *Survey method*, variable level CV_OE was found to be significantly less when compared to other survey methods (Table 1). This is consistent with the literature, where published CV studies compare open-ended to dichotomous choice questions and show that values from the dichotomous choice method equal or exceed those of the open-ended method in every case (Balistreri et al. 2001). *Year* had a slightly positive slope, indicating that respondents were WTP a greater percentage of their income each year towards protecting water quality (Table 1). The increase in WTP associated with *Year* suggests, after accounting for inflation and increase in income, that there is a growing demand for protecting water quality from pollution. This demand may be a result of increased visitor numbers and expenditures by tourists (Lee et al. 2009; Zhang and Lee 2007). Contingent valuation methods have been found to provide a consistent and reliable measure of total value (Carson et al. 1995; Loomis 1989), and therefore a general trend in increasing WTP to prevent water pollution appears to be reasonable due to pressures from population growth and demand for clean water. Carson et al. (1995) also found, from interviews taken two years apart, no significant temporal sensitivity in WTP to protect Prince William Sound from a future oil spill. Thus, our results may suggest that public views on water pollution may not have not reached "steady state" due to pressures from population growth and an increasing demand for clean water.

Systematic Variation in Socio-economic and Site Variables

Median household income was significant and showed a positive exponential correlation with WTP (Table 1). The WTP increases approximately $3.00 for every $10,000 increase in income. We found a slight exponential increase in income with an increase in WTP is reasonable when interpreted using basic micro-economic concepts. The ratio of percent change in income and change in demand for protecting water quality was less than one and according to the income elasticity of demand theory, this indicates that clean water is a necessity good and that people should be WTP more to protect as their income increases.

Region was the only variable significant at $p<0.10$ and WTP estimated for SOUTH was significantly lower compared to all other non-southern states (Table 1). The negative slope associated with SOUTH signifies that individuals in states in the southern US are WTP less to protect "good" water quality (Table 1). In contrast, Johnston et al. (2005) found that WTP to improve water quality in

Table 1. Estimated multiple regression model of water protection valuation function (dependent variable is natural log of annual value per individual)

Variable category	Level [a]	Coefficient (SE)
Intercept	Intercept	-0.883 (0.886)
Survey Method	CV_OE	-0.591** (0.220)
Year	YR_INDX	0.091*** (0.012)
Weighting	RR_COFF	0.897** (0.388)
Median household income	INCOME	0.058*** (0.000)
Region	SOUTH	-0.414 (0.259)
Resource	RIVER	-1.072*** (0.209)
Scale	DR_BSN	0.821** (0.340)
Scale	SGL_SITE	-1.294*** (0.415)
Program	PRG_AE	-2.990*** (0.209)
Sample size		43
R2 adjusted		0.8847
Standard error		0.246
F-statistic (degrees of freedom)		28.136* (9)

[a] Levels within each variable category were systematically compared against a corresponding reference variable to calculate a regression coefficient.

*** Significant at $p < 0.01$, ** Significant at $p < 0.05$, * Significant at $p < 0.10$

already polluted waters was higher in the southeast compared to states in the western and midwestern US. The results of our and Johnston et al.'s (2005) studies suggest that there are systemic differences in attitudes and preferences for resource characteristics among regions and states (Rosenberger and Loomis 2000; Shrestha and Loomis 2003). Our estimates suggest that public outreach and land owner assistance programs need to continue to promote proactive protection of the few remaining "well conserved" water resources in states in the southern US.

For *Resource*, a categorical variable, WTP for RIVER was significantly lower compared to all other resources (Table 1). The negative slope associated with RIVER indicates that respondents are WTP less to protect rivers compared to other water bodies. Johnston et al. (2005) also found that WTP for rivers was lower when compared to lakes and saltwater estuaries; however, another meta-analysis of recreational values by Shrestha and Loomis (2003) had mixed results in WTP among lakes and rivers based on the type of econometric model used. Intuitively, rivers might provide fewer services compared to other freshwater resources since, for example, lakes on average may offer better swimming and fishing benefits and wetlands may offer better water purification services and wildlife habitat than rivers. Desvousges et al. (1992) mentions that a problem with using existing studies for benefit transfer is the variation in the quality of parameters and the lack of necessary parameters across studies. Therefore, a lack of consistency in WTP values from the literature for a specific type of resource across studies might be due to inherent variation in the type and number of benefits being measured in different studies.

Scale showed that WTP for DR_BSN was higher and SGL_SITE was lower compared to the reference level, statewide (Table 1). When considering the effects of scale, we found programs that protected a single site had the lowest WTP, suggesting that there may be fewer ecosystem services available at a single site compared to multiple sites located throughout a drainage basin or even statewide. This is in line with demand theory that as the quantity of the good increases so does WTP. Also, WTP increased for programs that covered a drainage basin; however, it decreased slightly when the program was implemented statewide. This slight decline in WTP might be due to increased distance to the resource implying increased travel costs or budget constraints; hence, the individual seeks a closer substitute. Additionally, information about a distant resource may be limited and the individual might assume that a change in a resource-- outside their immediate location--would not affect their individual utility. Heberlein et al. (2005) argues that when respondents have more "perfect' information and greater held values towards a particular region, they are likely to assign a higher WTP value. The use of scale or scope as criteria for validity in CV has been controversial since evidence was presented by Kahneman and Knetsch (1992) that respondents to CV surveys do not assign different values to goods that differ in scope. Conversely, Carson et al. (2001) found that responsiveness to scale and scope appears to have improved over time due to better study design and implementation. Evidence of systematic variation in scale/scope can also be found in other recent meta-analysis literature (Brouwer and Spaninks 1999; Johnston et al. 2005; Poe et al. 2000; Rosenberger et al. 1999).

Finally, for the categorical variable *Program*, WTP for PRG_AE was significantly less than the reference variable PRG_WQP indicating that respondent's preferences are different for programs that used land acquisition or easements compared to non-specific environmental programs (Table 1). The negative slope associated with government programs that use land acquisition or easements suggest that the respondent's level of utility decreased when information about the proposed program was revealed. (Table 1). Johnston and Duke (2007) found similar results for different types of agricultural land preservation programs and if a public agency was implementing the program. The authors also concluded that systematic preferences for land preservation policy process attributes may emerge if they appear to influence utility and serve as proxies for unobserved land use outcomes. These preferences may be guided by already established attitudes and beliefs about how forests should be used and who should manage them. For example, respondents might assume that conservation easements are less likely to provide access than a fee simple purchase (McGonagle and Swallow 2005). Alternately, respondents might maintain a systematic preference for government involvement in land preservation, or believe that certain policy strategies represent an inappropriate use of public authority (Johnston and Duke 2007). In contrast, in the absence of information, such as the proposed non-specific programs, some respondents might have assumed that the process used to implement the program would not reduce their utility and risk overestimating what they would be willing to pay. The results of this analysis suggest that valuation studies that do not specify key aspects of the proposed program, such as implementation process and implementing organization, may not fully capture important preferences which may result in eliciting higher end WTP values.

Benefit Transfer Estimates

Findings of this meta-analysis suggest a wide range of systematic and intuitive patterns influencing WTP for maintaining or protecting water quality in well conserved aquatic systems and suitable for use in a BT context. The analysis indicates that while WTP is sensitive to elicitation methods, it is also systematically influenced according to region in the United States or within an individual state, type of resource, scope of program, and attributes of the water quality protection program. To better demonstrate the use of a benefit transfer method, below, we use four policy sites as case studies: the Florida panhandle, North Florida, Central Florida and South Florida. For each of these studies, model attributes were adjusted for two situations, or scenarios, in each region or state to better estimate WTP for programs that protect all water resource types using either (1) acquisition or easements as conservation tools, or (2) nonspecific programs where the policy tool is not specified.

Application of Benefit Transfer

When conducting a BT, it is expected that the variable level assignments for resource will be largely determined by the characteristics of the proposed policy. However, the literature provides little guidance with regard to the specification of variables characterizing study methodology such as year index and survey format. Omitting the methodological variables from this model would lead to systemic changes in the remaining model parameters therefore in this case the omission of study variables appear unjustified from a statistical perspective. The equation below demonstrates how a benefit transfer of WTP values was conducted for water quality protection programs that use acquisition or easement approaches in north Florida using coefficients calculated for each variable from the meta-analysis. The model is specified as

$$\text{Ln(WTP)} = \alpha + \beta_{\text{Survey}} + \beta_{\text{Year}} + \beta_{\text{Income}} + \beta_{\text{Region}} + \beta_{\text{Resource}} + \beta_{\text{Scope}} + \beta_{\text{Program}}$$

where Ln(WTP) is the natural log of annual individual WTP. The systematic variation associated with Survey and Year variables was removed by multiplying the coefficient by the mean reported value. The coefficient for Income was multiplied by the reported annual household income (2010 dollars) for each region (2000 United States Census Bureau, factfinder.census.gov): Florida panhandle= $31,755; north Florida= $35,916; central Florida= $36,822; and south Florida= $66,113. Site variable Region was adjusted for SOUTH, Scope adjusted for DR_BSN, Resource adjusted for the reference condition and Program was adjusted for PRG_AE as well as the reference condition. From the above equation, the predicted Ln(WTP) was transformed back to the desired WTP estimate using the following equation:

$$\text{WTP}=e^{(x+MSE/2)}$$

where x is the predicted LnWTP and MSE is the regression mean square error. Individual WTP value was then multiplied by 2.5 to calculate annual household WTP (United States Census Bureau, factfinder.census.gov) and the transformed WTP value was then applied to the policy site based on the number of households in each region of Florida.

Results and Discussion of Benefit Transfer

The annual household WTP ranged from $3.32 in the panhandle to $4.79 in central Florida (Table 2) for programs that used acquisition or easements as conservation tools to protect all surface water resources within a drainage basin. Total annual WTP was $1,714,034 in the Florida panhandle; $4,162,010 in north Florida; $7,279,996 in central Florida; and $3,933,155 in south Florida for a statewide total combined annual value of almost $17 million. Households' annual WTP for non-specific programs or programs that do not use acquisition or easement approaches to protect all water resources ranged from $64.81 in the panhandle to $94.01 in central Florida. Total annual WTP was $33,417,694 in the Florida panhandle; $81,564,757 in north Florida; $142,802,599 in central Florida; and $77,099,751 in south Florida, for a total combined annual value of almost $335 million for the entire state of Florida. The WTP value estimated from non-specific programs are more applicable to programs such as the Florida Forest Stewardship Program (FSP) since it promotes forest and water resource conservation without using land acquisition or conservation easements. This result shows that there is likely a significant amount of public support for programs such as the FSP based on expected water quality benefits.

Table 2. Annual household Willingness to Pay (WTP) values (2010 USD) for two water quality maintenance-protection programs that protect all water resources in the Florida panhandle, north Florida, central Florida and south Florida

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

Overall, our results show the substantial value that individuals are expected to place on well conserved water resources and the amount of economic resources that could be allocated towards polices that protect water quality in these systems. The BT also shows that Floridians are expected to place a significantly lower value on programs that disclose that land will be removed from private ownership. When developing environmental policies or using forest conservation to protect water quality, policy makers should strongly consider that programs that use land acquisition and conservation easements might have less public support compared to other types of programs such as land owner incentive and assistance programs. Unfortunately, we could not assess the value of different conservation tools other than acquisition or easements, due to a lack of available CV studies. In the larger body of available valuation studies there is limited information on how incentives, education programs and other land owner assistance programs contribute to variation in WTP to protect water quality and how the value of these programs compare to WTP for acquisition/easement instruments as well as non-specified programs. More research is needed to identify how information about the proposed policy process or conservation tools contributes to a more rational estimate of individual welfare and how providing this information can reduce unexplained variation related to the unknown and assumed preferences of the respondents. However, it is reasonable to assume that our econometric model can provide useful guidance regarding the general magnitudes of welfare effects within a benefit transfer context- at least with regard to potential WTP adjustments associated with acquisition or easement approaches as well as type of resource, scope and geographical context. Therefore, the results of this BT can be used to (1) estimate the welfare effects of protecting/maintaining water quality to be used in a cost/benefit analysis, (2) estimate the total amount of potential funds available in each region to support various water quality protection programs through taxes or fees, and (3) gain a better understanding of the priorities of individuals regarding forest conservation and water resource protection strategies.

Conclusions

This study presented a meta-analysis conducted to estimate characteristics of WTP for programs that maintain or protect water quality in well-conserved aquatic systems. The WTP estimates of the different regions can be used to derive indirect economic value of programs, such as the FSP, that help protect water quality by conserving forest lands. Model results are promising with regard to the ability of the meta-analysis to identify systematic components of WTP and reveal patterns that may be unapparent from stated preference models considered in isolation. We found intuitive and statistically significant relationships between WTP and several independent variables. In particular, WTP is sensitive to geographical region, type of resource, scope of the water quality protection program, and a variety of study design attributes. Our findings also indicate that conservation tools used by programs, such as acquisition or easements, influences WTP and also that WTP to protect water resources has increased over time, suggesting a growing demand for protecting well-conserved aquatic systems. While this meta-analysis can explain a substantial proportion of systematic variation in WTP for acquisition or easement approaches, we found that the model provided little guidance about WTP for other types of conservation tools, such as incentives for landowners, education programs, and other assistance programs. Further research is needed for a better understanding of how the proposed policy process and associated tools contributes to WTP. However, our findings suggest there is a large total annual WTP to use forest conservation programs and practices to protect water quality in well conserved aquatic systems in Florida.

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Appendix 1.

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

Study	Observation per study.[a]	Program process	Water body type[b]	Scale	Valuation methodology	US State	Adjusted individual annual WTP values (2010 dollars)[c]
Aiken (1985)	4	Not specified	River and lakes	Statewide	CV- iterative bidding and open ended	Colorado	13.43-31.02
Blaine and Smith (2006)	2	Easement	River/stream	Region in state	Other	Ohio	7.59-13.18
Blaine et al. (2003)	1	Easement	All water resources	Region in state	CV-Dichotomous choice	Ohio	11.06
Blaine and Lichtkoppler (2004)	1	Easement	Wetland	Region in state	Dichotomous choice	Ohio	17.53
Carman et al. (1992)	1	Acquisition	Wetland/estuary	Region in state	CV-open ended	Ohio	2.87
Cho et al. (2005)	2	Easement	All water resources	Region in state	CV-Dichotomous choice	Oregon	4.95-9.85
Condon (1996)	2	Acquisition and Easement	All water resources	Region in state	Attribute based choice experiment	North Carolina	17.07-20.37
Cooksey and Theodore (1995)	1	Easement	All water resources	Region in state	Other	New Hampshire	18.60
Giraud et al. (2001)	1	Not specified	River/stream	Region in state	CV-Dichotomous choice	Colorado	237.77-269.73
Greenly et al. (1981)	5	Not specified	River/stream	Region in state	CV-Dichotomous choice	Colorado	8.38-59.34
Hanemann et al. (1991)	2	Not specified	Wetland/estuary	Region in state	CV-Dichotomous choice	California	82.32-139.32
Holmes et al. (2004)	3	Not specified	River/stream	Specific site	CV-Dichotomous choice	North Carolina	12.74-25.12

Characteristics of valuation studies estimating Willingness To Pay (WTP) for the maintenance or protection of benefits associated with well conserved aquatic resources *continued*

Study	Observation per study.[a]	Program process	Water body type[b]	Scale	Valuation methodology	US State	Adjusted individual annual WTP values (2010 dollars)[c]
Mannesto et al. (1991)	2	Not specified	Wetland/estuary	Specific site	CV-Payment card	California	29.43-54.24
Petrolia (2011)	2	Not specified	Wetland/estuary	Region in state	CV-Dichotomous choice	Louisiana	221.11-266.48
Sanders et al. (1990)	5	Not specified	River/stream	Region in state	CV-open ended	Colorado	14.15-32.08
Shrestha and Alavalapati (2004)	2	Land owner incentives	Lake	Specific site	Other	Florida	14.84-34.92
Sutherland and Walsh (1985)	4	Not specified	River/stream	Region in state	CV-open ended	Montana	6.05-21.64
Whitehead (1990)	2	Not specified	Wetland/estuary	Specific site	Other	Kentucky	4.05-8.78

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

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

[c]All values were adjusted for inflation to the 2010 U.S. dollar value according to the Consumer Price Index.

Appendix 2.

Meta-analysis variables and descriptions

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

Carbon Stocks on Forest Stewardship Program and Adjacent Lands

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Introduction

Forests have an important role in global carbon cycle, because they can sequester and store carbon dioxide in the form of biomass (US EPA 2005). In a forest, carbon derived from using CO_2 during photosynthesis is stored in various pools: carbon in standing biomass, carbon in dead and fallen material, carbon belowground, and carbon in forest products (Johnsen et al. 2001). Terrestrial carbon sequestration is one of the ecosystem services highly recognized for its economic value in the market place (Stern 2007; IPCC 2006; Tallis et al. 2010). In the Kyoto Protocol (treaty addressing international climate), there is a mechanism to sell carbon credits from projects to others who need to reduce their emission. There are markets such as the Chicago Climate Exchange and European Climate Exchange for trading carbon (Tallis et al. 2010). The current market only pays for carbon sequestered in forests, but the last UN Framework Convention on Climate Change has accepted to provide financial incentives to "reduced emissions from deforestation and degradation" or REDD (Mackey et al. 2008). Under the REDD framework, landowners could get paid for the amount of carbon stored in their property, and not releasing the stored carbon through deforestation and degradation.

The Forest Stewardship Program (FSP) has long been recognized as an opportunity for forest landowners to voluntarily manage their forests for multiple uses. The program has also served as a framework for forest conservation, thus maintaining the ecosystem services derived from these lands. An increasing threat to NIPFs, such as FSP, is a lack of understanding about, and value placed on, the many benefits and services NIPF lands provide to society. Florida currently has approximately 2,700 private forests enrolled in the Stewardship Program. Valuation of carbon stored in these private forests and landowners' awareness about the REDD framework will provide incentive to landowners to conserve their forests. It could be an important tool for the state and policy makers to encourage forest conservation. In this study, we will quantify carbon stored in properties enrolled in FSP and estimate their economic value.

Methods

We used FSP management plan and property boundary spatial data provided by Steve Jennings, from the Florida Forest Service. Although in 2010 there were over 177,000 hectares in the FSP, analyses are based on the 99,800 acres that had property boundary data. Georeferenced Forest Inventory and Analysis (FIA) data were also used for analyzing carbon stocks in all lands classified as "forests" in Florida according to condition status classification (condition status code=1) of FIA. After 1998, FIA is required to collect data annually; a fraction of the plots within a state are measured annually. In Florida, 20% of the plots within the state are collected each year. We used data from 2002 to 2007, which completed a full cycle of annual plot measurements in Florida. Due to privacy reasons, FIA does not release specific plot locations. As a result, specific plot location on Forest Stewardship Program (FSP) properties with property boundary data could not be identified. However, Sam Lambert from the USDA FS FIA provided ARC GIS shape files of FSP properties that had FIA plots within their boundaries and a 1-mile buffer around each FSP with FIA plots. Spatial information of FIA plots within FSPs and the buffers resulted in 532 FIA plots on or within 1 mile of FSP properties. A total of 43 plots were within FSPs and 489 plots were in the buffer.

The FIA data consist of information on: forest ownership, forest types, disturbance, year the disturbance occurred, site quality, stand ages, tree aboveground carbon, tree belowground carbon, understory aboveground carbon, understory belowground carbon, carbon down dead, carbon standing dead, carbon litter, and carbon soil organic matter.

From the carbon pools provided in FIA data (Table 1), we identified four carbon pools in Florida forests for this analysis: aboveground, belowground, dead, soil organic carbon, and total carbon (Table 2). The FIA plot data provided tree-level information on carbon (pounds per tree) in the aboveground portion of live trees > 2.5 cm and dead trees >12.5 cm. This per tree value was converted to per-acre (which was later converted to Mg C/ha) value using the conversion factor provided for trees in macroplots (0.999), subplots (6.01), and microplots (74.96). The plot level tree aboveground carbon (tons/acre) value was calculated by summing all the individual tree values within a plot, and per plot tree belowground carbon (tons/acre) was calculated using similar procedure as for tree aboveground carbon. For this analysis, all the carbon values were converted to Mg C/ha (Table 2).

We also calculated carbon stocks for the 4 carbon pools on FSPs and forested areas within 1 mile of FSPs. To determine statistical differences in carbon values between FSP and non-FSP, we used a t-test. Carbons stocks were calculated separately for the four FIA regions in Florida: northeastern, northwestern, central, and south Florida. We also calculated carbon stocks for different forest types in the four regions of Florida. Forest types were identified by combining forest types provided in FIA data set (Table 3). For more information on data collection and description, refer to Woundenberg et al. (2010).

Table 1. Carbon stocks by pool identified in USDA Forest Service Forest Inventory and Analysis data

Carbon pools	Description
Tree aboveground	Carbon in bole, crown, branches, and stump of live trees > 2.5 cm and dead trees > 12.5 cm
Tree belowground	Carbon in coarse roots (>2.5 mm) for live (>12.5 cm) and dead (>12.5 cm) trees
Understory aboveground	Carbon in aboveground portion of seedlings, shrubs, and bushes
Understory belowground	Carbon in belowground portion of seedlings, shrubs, and bushes
Carbon down dead	Carbon in woody material (>7.5 cm) and their stumps and roots > 7.5 cm
Carbon litter	Carbon in fine woody debris, fine roots, and organic forest floor above the mineral soil
Soil organic carbon	Soil organic carbon to a depth of 1m.

Table 2. Carbon stocks identified by pool according to the FIA data

Carbon pools	Description
Aboveground (Mg C/ha)	Sum of tree aboveground and understory aboveground
Belowground (Mg C/ha)	Sum of tree belowground and understory belowground
Carbon dead (Mg C/ha)	Sum of down dead, litter, and standing dead
Soil organic carbon (Mg C/ha)	Soil organic carbon to a depth of 1m.
Total carbon	Sum of aboveground, belowground, carbon dead, and soil organic carbon

Table 3. Forest types used in the current study after combining the forest types described in the FIA data

Forest types	FIA Forest types
Longleaf pine	Longleaf pine, Longleaf pine/oak
Slash pine	Slash pine, slash pine/hardwood
Other pine hardwood	Loblolly pine, Sand pine, Pond pine, Shortleaf pine, Loblolly pine/hardwood, Other pine/hardwood
Oak hickory	Post oak/black jack oak, White oak/red oak/hickory, Sassafras/persimmon, Yellow poplar, Southern scrub oak, Red maple/oak
Oak gum cypress	Sweetgum/nuttall oak/willow oak, Overcup oak/water hickory, Bald cypress/water tupelo, Sweetbay/swamp tupelo/red maple, Bald cypress/pond cypress.
Mixed upland hardwood	Mixed upland hardwood/tropical hardwood/exotic hardwood

We also estimated the total carbon stored in Suwanee watershed. The carbon value was estimated for 63 sub-watersheds. Two groups of watersheds with no FSPs and with more than 5 percent of the total area covered by FSPs were created to compare the carbon values. Because the carbon value within each group was not normally distributed, we used a Wilcoxon rank sum non-parametric test to compare carbon value between watersheds with and without FSP properties.

The economic value of carbon was based on the carbon prices provided by Point Carbon (PointCarbon market outlook, 2010; Charnley et al. 2010) which conducted a survey of carbon traders (N=4767) in late 2010, and reports that most carbon traders expect it to be in the range of $5 - $40 per Mg C (or $1.36 - $10.91 per ton co2e) on average through 2020 (PointCarbon market outlook, 2010). The average expected price is $19 per Mg C (or $5.18 per ton co2e).

Results

Carbon stocks were calculated for FSP properties and forested areas within a mile from forest stewardship properties. We compared carbon stocks (Mg C/ha) between FSP properties and the adjacent 1-mile buffer. Since most of our forest stewardship properties are in north Florida, we only analyzed FSP and non-FSP in northeastern and northwestern Florida.

Northwestern Florida

The average total carbon stock for FSP properties and 1-mile buffers (Buffer) around FSP properties in Northwestern Florida was 166 Mg C/ ha and 138 Mg C/ha, respectively. Total carbon and the 4 carbon pools were also compared between FSP property and Buffers. Although FSP property had higher carbon stock for all the carbon pools (Table 4, Figure 1) than the 1-mile buffers, t-tests indicated that carbon pools between the two were not statistically significant. In northwestern Florida FSP, mixed upland hardwood forest type had the highest aboveground carbon stock, followed by slash pine, but total carbon stock and soil organic carbon was higher for oak gum cypress forest type (Table 5). In forested areas within 1 mile from forest stewardship properties, oak gum cypress forest types had the highest aboveground, soil organic, and total carbon stock (Table 6). We did not do any statistical comparison due to a reduced sample size (<5 plots) for some forest types.

Table 4. Carbon stock (Mg C/ ha) for different carbon pools for Forest Stewardship Property and a mile buffer from forest stewardship property in northwestern Florida

Carbon pools	Forest Stewardship Property			Buffer		
	Min	Mean	Max	Min	Mean	Max
Aboveground	8	33	100	1.14	28	133
Belowground	1.3	6.8	23	0.2	5.6	28
Carbon Dead	9.3	15.5	22	1.9	13.7	29
Soil	67	111	175	25	90	174
Total carbon	104	166	266	32	138	362

Table 5. Average carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within forest stewardship properties in northwestern Florida

Forest types	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Mixed upland hardwood	40 (35)	8 (7)	9 (5)	77 (27)	135 (22)
Oak gum cypress	22 (12)	4.2 (2.4)	16 (3)	174 (1.5)	216 (15)
Other pine hardwood	25 (15)	5.1 (3)	17 (1)	76 (4)	124 (15)
Slash pine	35 (19)	7.5 (4)	18 (1.5)	111 (11)	172 (23)

Table 6. Average carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within a mile of (buffer) forest stewardship properties in northwestern Florida

Forest types	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Longleaf pine	29 (10)	6 (2)	18 (1)	102 (8)	154 (17)
Mixed upland hardwood	18 (3.5)	3.3 (0.7)	9 (1.2)	47 (5)	78 (7.5)
Oak gum cypress	46 (8)	9 (2)	19 (1)	171 (3)	246 (12)
Oak hickory	12 (7)	2 (1.5)	10 (1.3)	50 (1)	73 (10)
Other pine hardwood	16 (4.2)	3 (0.8)	15 (0.5)	78 (1)	113 (5)
Slash pine	28 (7)	6 (1.6)	17 (0.8)	109 (5)	160 (11)

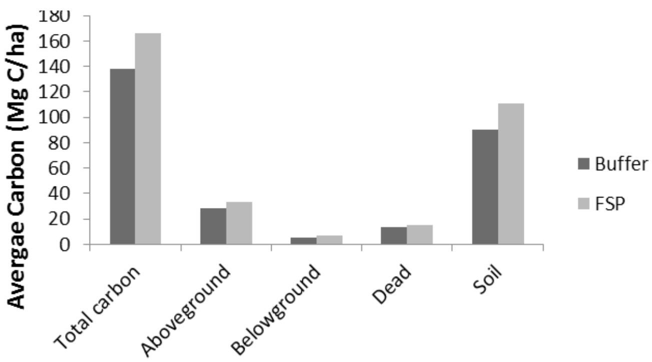

Figure 1. Carbon stock for forest stewardship properties (FSP) and forested areas within a mile (buffer) of forest stewardship properties in northwestern Florida

Northeastern Florida

The average total carbon stock for FSP in northeastern Florida was 143 Mg C/ ha, and 102 Mg C/ha for adjacent 1-mile buffers. All 5 carbon pools in FSP, except aboveground and belowground carbon stock, were higher than the 1 mile buffers, but differences were not statistically significant (Table 7 and Figure 2). In northeastern Florida FSP, slash pine forest type had the highest aboveground, belowground, dead, and total carbon stock (Table 5), but soil organic carbon stock was the highest for the oak gum cypress forest types (Table 8). In forested areas with 1 mile of FSP, oak gum cypress forest type had the highest aboveground, belowground, soil and total carbon stock (Table 9). Some forest types had a very low sample size; as a result standard error of estimation was not reported (Table 8), and no statistical comparisons were made.

Table 7. Carbon stock (Mg C/ ha) for different carbon pools for Forest Stewardship Property and a mile buffer from forest stewardship property in northeastern Florida

Carbon pools	Forest Stewardship Property			Buffer		
	Min	Mean	Max	Min	Mean	Max
Aboveground	4.3	28	94	1.3	31	147
Belowground	0.5	5.6	18	0.18	6.5	29
Carbon Dead	9	16	47	3	14	28
Soil	57	103	174	12	91	174
Total carbon	116	153	245	17	143	378

Table 8. Average Carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within Forest Stewardship Properties in northeastern Florida

Forest types	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Longleaf pine	4.5(0.05)	0.5 (0.005)	13 (1.2)	121 (1.1)	139 (1.2)
Mixed upland hardwood	14.6 (10)	2.6 (2)	25 (17)	77 (16)	120 (5)
Oak gum cypress	15 (8.5)	2.8 (1.6)	11.5 (2)	174 (1.5)	203 (10)
Oak hickory	6.2 (NA)	1 (NA)	7 (NA)	50 (NA)	64 (NA)
Other pine hardwood	16 (NA)	3.2 (NA)	16 (NA)	80 (NA)	116 (NA)
Slash pine	67 (27)	14 (5.5)	18 (0.8)	121 (1)	221 (33)

Table 9. Average Carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within a mile of (buffer) Forest Stewardship Properties in northeastern Florida

Forest types	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Longleaf pine	15 (5.5)	3 (1.1)	17 (1.5)	94 (12)	129 (14)
Mixed upland hardwood	25 (5)	4.7 (0.9)	9.3 (1.1)	48 (5)	87 (9)
Oak gum cypress	58 (11)	12 (2.2)	18 (1.5)	174 (3)	263 (15)
Oak hickory	11 (3.5)	1.8 (0.7)	11 (1.1)	50 (1.1)	74 (5)
Other pine hardwood	19 (5.5)	4 (1.2)	18.5 (1.2)	78 (1.1)	120 (7.5)
Slash pine	31 (4.5)	7 (1)	17 (0.5)	113 (3.1)	168 (6.3)

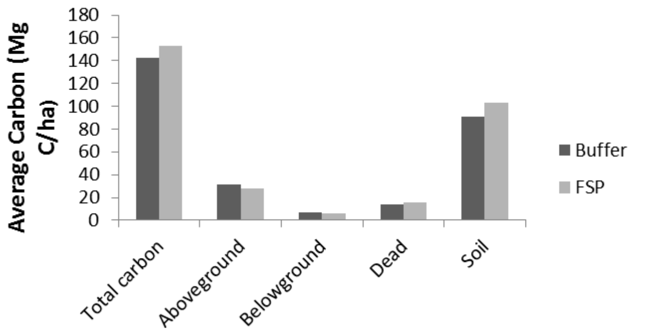

Figure 2. Carbon stock for forest stewardship properties (FSP) and forested areas within a mile (buffer) of forest stewardship properties in northeastern Florida

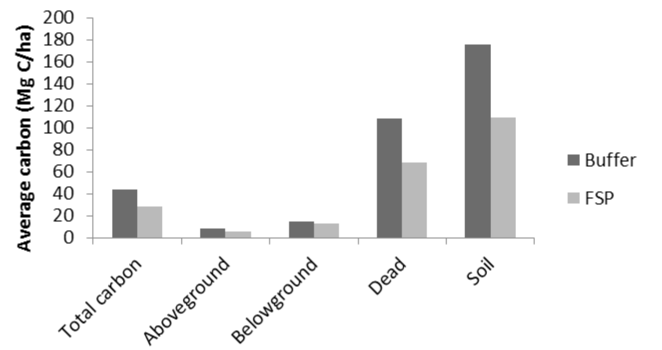

Figure 3. Carbon stock for forest stewardship properties (FSP) and forested areas within a mile (buffer) of forest stewardship properties in central Florida

Central Florida

The average total carbon stock for FSP and 1-mile buffers in central Florida was 163 Mg C/ha and 176 Mg C/ha, respectively. All the carbon pools, including the total carbon were higher in buffer than in FSP (Table 10 and Figure 3), but we did not make any statistical comparison due to lower sample size of FSP (<5) with FIA plots. In central Florida, FIA plots that are within FSPs had only longleaf pine forest type (Table 11). In forested areas within a mile from FSPs, mixed upland hardwood forest type had the highest aboveground carbon, but the total carbon stock was higher in oak gum cypress forest type (Table 12). Oak hickory forest type had only one plot to report the standard error (Table 12).

Southern Florida

For southern Florida, there were no FIA plots within the forest stewardship properties; therefore, we calculated carbon stock for forested areas within a mile of FSP (buffer; Table 13). Also, FIA plots had only one forest type represented (Table 14).

Economic valuation of carbon

Table 15 presents a range of economic values for Mg C/ha, which were calculated by multiplying the minimum, mean, and maximum price ($per Mg C) with minimum, mean, and maximum total carbon (Mg C/ha) for different FIA units. The average dollar value per ha of carbon stored were $3154, $2907, $3097, and $3610 for northwestern, northeastern, central, and southern FIA units, respectively (Table 15). The total value of geographically weighted carbon stored in FSP lands is around $300 million dollars (Table 16). We calculated the total value for the entire state by summing the product of the average per hectare ($/ha) value for each FIA units and corresponding total area (Table 16).

Table 10. Carbon stock (Mg C/ ha) for different carbon pools for Forest Stewardship Property and a mile buffer from forest stewardship property in central Florida

Carbon pools	Forest Stewardship Property			Buffer		
	Min	Mean	Max	Min	Mean	Max
Aboveground	7.5	42	76	4	44	68
Belowground	1.2	8.5	15.7	2.5	8.5	18
Carbon Dead	12.5	19	24	3.7	15	26
Soil	63	94	121	25	108	174
Total carbon	89	163	237	38	176	308

Table 11. Average Carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within forest stewardship properties in central Florida

Forest types	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Longleaf pine	42 (34)	8.5 (7)	19 (5.5)	94 (27)	163 (74)

Table 12. Average Carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within a mile of (buffer) forest stewardship properties in central Florida

Forest types	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Mixed upland hardwood	51 (42)	10 (8)	13 (6)	68 (18)	142 (48)
Oak gum cypress	47 (17)	10 (3.5)	22 (2)	174 (2.5)	253 (19)
Oak hickory	63 (NA)	11.8 (NA)	16.5 (NA)	50 (NA)	141 (NA)

Table 13. Carbon stock (Mg C/ha) for different carbon pools within a mile from forest stewardship property in southern Florida

Carbon pools	Buffer		
	Min	Mean	Max
Aboveground	6	24.5	43
Belowground	0.89	4.6	8.3
Carbon Dead	3.7	14	27
Soil	105	147	190
Total carbon	115	190	265

Table 14. Average carbon stock (Mg C/ha) and SE (parenthesis) for different forest types within a mile of (buffer) forest stewardship properties in southern Florida

Forest type	Aboveground	Belowground	Carbon Dead	Soil	Total carbon
Mixed upland hardwood	25 (18)	4.5 (3.7)	14 (10)	148 (43)	191 (75)

Table 15. Economic value ($/ha) of total carbon stored (Mg C/ha) in Forest Stewardship Properties and buffer (forests within a mile from FSPs). The values were calculated based on minimum, mean, and maximum value for price and total carbon per ha.

FIA units	Price range	Total Carbon Value ($/ha)			Buffer Total Carbon Value ($/ha)		
		Min	Mean	Max	Min	Mean	Max
Northeastern	Min	580	765	1225	85	715	1890
	Mean	2204	2907	4655	323	2717	7182
	Max	4640	6120	9800	680	5720	15120

Table 15. Economic value ($/ha) of total carbon stored (Mg C/ha) in Forest Stewardship Properties and buffer (forests with a mile from FSPs). The values were calculated based on minimum, mean, and maximum value for price and total carbon per ha. *continued*

FIA units	Price range	Total Carbon Value ($/ha)			Buffer Total Carbon Value ($/ha)		
		Min	Mean	Max	Min	Mean	Max
Northwestern	Min	520	830	1330	160	690	1810
	Mean	1976	3154	5054	608	2622	6878
	Max	4160	6640	10640	1280	5520	14480
Central	Min	445	815	1185	190	880	1540
	Mean	1691	3097	4503	722	3344	5852
	Max	3560	6520	9480	1520	7040	12320
Southern	Min	575	950	1325	n/d	n/d	n/d
	Mean	2185	3610	5035	n/d	n/d	n/d
	Max	4600	7600	10600	n/d	n/d	n/d

Note: Min=Minimum, Max=Maximum, n/d=not determined

Table 16. Total economic value of carbon stored in Forest Stewardship Program (FSP) lands in each Florida Forest Inventory and Analysis (FIA) region. The value was estimated by multiplying average economic value ($/ha; assuming $19 per Mg C) times total of current and active (2010) FSP hectares in each FIA region.

FIA region	Total FSP Area (ha)[a]	Average value ($/ha)	Total value ($)
Northeastern	55,695	2,907	161,905,365
Northwestern	32,562	3,154	102,700,548
Central	8,985	3,097	27,826,545
Southern	2,572	3,610	9,284,920
State-wide			301,717,378

[a]Only FSP properties with available spatial data were analyzed.

Lower Suwannee Analysis

At the sub-watershed level, the value of total carbon for sub-watersheds ranged from 182 Mg C/ha to 302 Mg C/ha, with an average of 220 Mg C/ha. Based on this, the total carbon stored in Suwanne watershed was approximately 26 million Mg. A non-parametric Wilcoxon rank sum test indicated that there was no difference in per ha carbon value between sub-watersheds without FSPs and sub watersheds with more than 5 percent of the total area covered by FSPs.

Discussion and Conclusion

The average total carbon value reported in the study for FSPs and buffers in different FIA units range from 143 to 190 Mg C/ha, which is within the range (74 to 280 Mg C/ha) reported for southeastern US (Heath et al. 2011), and also within the range (120-194 Mg C/ha) reported for tropical forests (Lal, 2005). In general, FSPs in Northeastern and Northwestern units had higher total carbon and all the carbon pools than outside buffer forests. This difference was not statistically significant. In central Florida, buffers had higher carbon than FSPs. We did not do any statistical comparison in central Florida due to lower sample size of FSPs. Among the forest types, oak gum cypress forest, mixed upland hardwood forest, and slash pine forest had higher amounts of carbon. The higher amount of total carbon in oak gum cypress forest is due to higher soil carbon, which is due to the peat deposition, and slower decomposition of organic matter in the soil. Prior studies have also shown that the hardwood forests had higher amounts of carbon stocks and wood production (Brown et al. 1999). Most of the plantations in Florida are of slash pine, and plantations are intensively managed to increase growth; therefore, they have higher amount of carbon.

The average expected dollar value ($/ha) of carbon for a property having average total carbon ranged from 2,907 to 3,610 (Table 15), which is higher than ~ $1,000/ha average value reported by Moore et al. (2011) for private forests in Georgia. They used a price range of $5 to $42/Mg C with an average price of $21, which is similar to the present study; however, they used 47 Mg C/ha as the average carbon value in the private lands. The carbon value used was lower than in the present study and also below the lower range reported in the studies described above. The total value of carbon stored in FSPs was $300 million, which is approximately four times ($80 million) the average carbon credits landowners will receive per year if all the pine plantations in Florida are managed under moderate intensity management (Mulkey et al. 2008).

National carbon markets are being developed. The American Clean Energy and Security Act passed in June 2009 through the US House of Representatives (none have passed the Senate) includes afforestation, reforestation, forest management, and reduced emissions from deforestation and degradation as carbon offset projects (Charnley et al. 2010). Voluntary carbon markets such as Chicago Climate Exchange (CCX) and over-the counter (OTC) transactions are also available in the US. California passed legislation in 2008, which supports the implementation of market-based strategies to regulate the six major greenhouse gases from major industries. Regional Greenhouse Gas Initiative was launched in 2008 by ten northeastern states to regulate emission of CO2 using a cap-and-trade system (Charnley et al. 2010). Under these circumstances, it will be useful to have a value of carbon stored in FSPs, and the information provided could be used to convince landowners and policy makers to conserve forests or manage forests for multiple uses.

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Managed Timber Production

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Introduction

Timber products are considered provisioning ecosystem services and are used to provide multiple private and social needs (MA 2005). The benefits of this ecosystem service, or good, are widely recognized and are more easily valued than other ecosystem services, because market prices exist for timber and many non-timber forest products (Vitousek et al. 1986, cited by Brauman et al. 2007; de Groot et al. 2010). According to the results of the survey realized by the University of Florida for this project, 61% of non-industrial private forest landowner respondents were more likely to manage their land for timber and 71% consider timber an important ecosystem service. Of the approximately 835 Forest Stewardship Properties in the State of Florida with active management plans and available Geographical Information Systems (GIS) data, 80% of these have timber production defined as an objective in their Forest Management Plans (FMPs; Figure 1 and 2). Therefore, landowners in the FSP can decide to manage their forest lands primarily to maximize the growth of merchantable timber or they can manage timber as a secondary objective and in a way that focuses on multiple resources (Duryea et al. 1992).

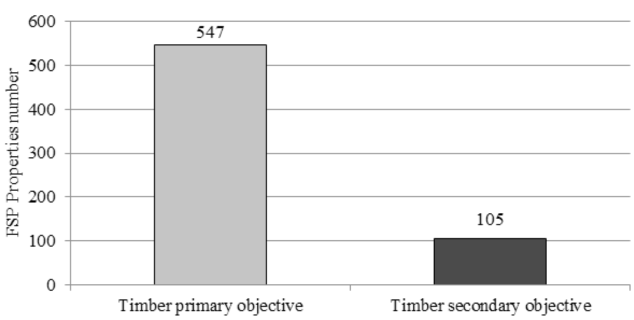

Figure 1. Forest Stewardship Properties (FSP), with available spatial data, that have timber production as an objective

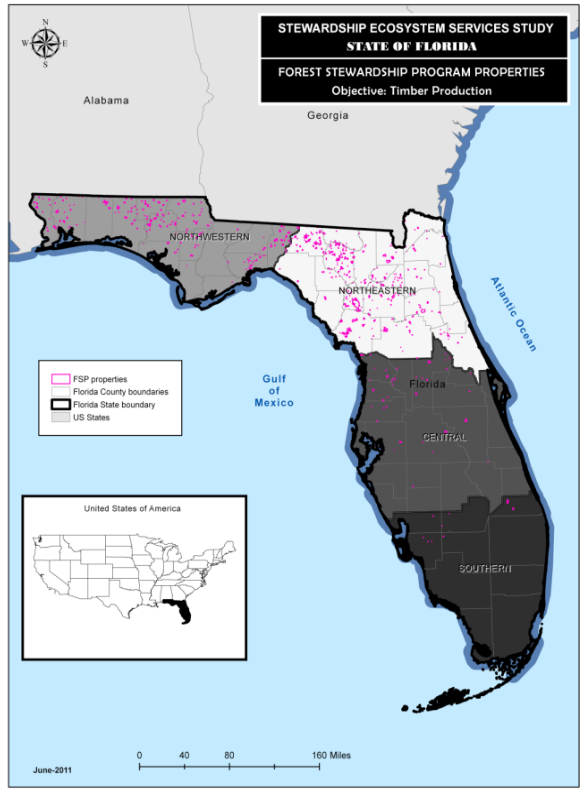

Figure 2. Forest Stewardship Program (FSP) properties that manage for timber production objectives in the four FIA units. The FSP properties shown are those with available spatial data.

Differences in terms of forest management will exist between, and among, private and public forests. Private forest landowners or entities with an exclusive right to harvest forest stocks have an incentive to maximize the net present value of economic returns over time. Therefore, forests with well-enforced property rights (e.g. private forests) will tend to have lower harvest rates and greater biological stocks at any point in time than open-access (public) forests (Nelson et al. 2011). Yet little is known in Florida about the differences in timber production between Non-Industrial Private Forests (NIPF) that prioritize timber versus those NIPF that prioritize multiple ecosystem services and goods such as recreation and water in addition to timber.

To asses these differences between these 2 types of NIPFs, we analyzed representative differences in timber production between: (1) Forest Stewardship Program properties (FSP) and (2) Non- Forest Stewardship Program properties that are within 1 mile of each FSP property (hereafter referred to as non-FSP). We used USDA Forest Service Florida Forest Inventory and Analysis (FIA) timber/biomass data and the InVEST Timber production model (Managed Timber production ecosystem service valuation model, http://www.naturalcapitalproject.org/InVEST.html) and FSP Geographic Information System (GIS) data provided by the Florida Forest Service, to analyze timber as an ecosystem service using two different management approaches or scenarios reflecting both FSP and non-FSP properties.

Methods

FIA Data

The FIA plot-level data were georeferenced by the USDA Forest Service, Southern Research Station, Forest Inventory and Analysis unit (Sam Lambert, USDA Forest Service, personal communication). The data were then analyzed according to the four Florida FIA units: northeastern, northwestern, central and southern Florida (Figure 2). We used plot-level FIA data from both FSP and Non-FSP forests to analyze key timber production indicators from 2002 to 2007 (FIA cycle 8 data). Three categories from the FIA that are often used for regional and statewide timber production estimates were analyzed: net volume (VOLCFNET), net annual merchantable growth (GROWCFGS), and volume of growing-stock for removal purposes (REMVCFGS) (Table 1). These categories provided individual tree data (cubic foot/tree) that was later converted to per acre estimates using the adjusted values provided in the FIA database. Once all tree data were summed to obtain plot-level data and converted to cubic meters per hectare, T-tests were used to determine statistical differences between FSP and non-FSP forests at a 95% of confidence level for volume (VOLCFNET) in Northeastern Florida while the Wilcoxon-Rank sum test was applied for the other categories.

InVEST Model Scenarios

Management objectives should determine forest characteristics and ecosystem services, so timber production modeling scenarios were based on whether timber production was a management objective of the Forest Stewardship Properties (Figure 2). The Integrated Valuation of Ecosystem Service and Tradeoffs model (InVEST), timber module analyzes the amount (biomass) and volume of legally harvested timber from natural forests and managed plantations based on harvest level and cycle information. The valuation components uses timber amounts and volume to estimate the economic value of the timber based on market prices, harvest and management costs, and discount rates (Tallis et al. 2011).

Because of different forest structure/management characteristics among all FSP properties across Florida (i.e. over 1,600 landowners across the state), two different modeling scenarios representing FSP timber management objectives were simulated using the InVEST model. Specifically, we developed 2 general and representative scenarios to estimate different timber production potentials in Florida's NIPF, assuming that (1) FSP properties manage for multiple use objectives following FSP criteria, and (2) Non-FSP properties manage for timber production as their primary management objective and do not follow FSP criteria. These two representative management objectives were modeled based on the amounts of timber harvested in the different scenarios and the estimated economic value of the harvested timber. The Managed Timber production model was developed using a representative set of current FSP

Table 1. Description of FIA categories identified for timber production (Woundenberg et al. 2010)

Categories	Description
VOLCFNET	Net cubic-meter volume of timber.
GROWCFGS	Net annual merchantable cubic-meter growth of a growing-stock trees on timberland. This is the net change in cubic-meter volume per year for a tree.
REMVCFGS	Cubic-meter volume of a growing-stock tree on timberland for removal purposes. Represents the cubic-meter volume of the tree at time of removal.

properties and their available GIS and Forest Management Plan (FMP) data. Two hundred forty two properties were selected according to whether timber harvesting was defined as a specific objective in the properties' FMP and where the forested area for the FSP property was greater or equal to 25 hectares (Chris Demers, UF-Florida Forest Stewardship Program, personal communication). The 2-model scenarios were analyzed according to a total of 76,000 hectares and the four FIA regional units.

As previously mentioned, the first model scenario, hereafter referred to as the FSP scenario, was developed based on the assumption that forest management follows FSP forest/timber management criteria. Conversely, the second scenario, hereafter referred to as the Non-FSP scenario, assumes non-FSP forest/timber management criteria were followed. Our definition of FSP criteria assumes that thinning is applied at the rate of 1-3 times per rotation for landowners that manage for multiple uses (i.e. Recreation, Aesthetics and Wildlife; M. Humphrey, Florida Forest Service, personal communication). For the FSP scenario, the thinning treatment assumed a 30% removal of the total biomass per hectare, whereas the Non-FSP scenario assumed no thinning treatments. For both scenarios, the primary timber harvest management objective was the use of clear-cuts and the secondary timber harvesting objective was the use of selective harvesting methods (i.e. harvesting a portion of trees in a stand). This assumption is based on Duryea et al. (1992), who reports that clear-cuts provide the highest financial return, so landowners, whose primary objective is timber production, should favor this method. Otherwise, landowners who choose timber management as a secondary objective may want to consider other alternatives such as selective cutting, shelterwood, or seed-tree methods (Appendix 3).

The input data are presented in Managed Timber Production Appendices and include model parameter description, units of measure, values assigned for the analyzed scenarios, and the source of each data set. Specific methods and sources used to obtain model scenario parameters are also listed in the Managed Timber Production Appendices. The model scenarios were based on data such as amount of timber biomass harvested in each cycle, harvest cost and timber market price to calculate timber volume and its economic value.

Results

FIA Data

The average net volume (VOLCFNET), average net merchantable growth (GROWCFGS), and average net volume of growing-stock for removal purposes (REMVCFGS) for FSP and non-FSP in the 4 Florida FIA units are shown in Tables 2-5 and Figures 3-6. Differences in the three categories for FSP and Non-FSP in the northeastern and northwestern Florida units were not statistically significant. Sample sizes for FSP in the central and southern Florida FIA units were insufficient (less than 5 FSP properties); therefore, statistical analyses were not performed.

Table 2. Timber volume (VOLCFNET), growth (GROWCFGS) and removal (REMVCFGS) for Forest Stewardship Program (FSP) properties and buffers (non-FSP properties) in northeastern Florida

Categories	Units	Forest Stewardship Property			Buffer		
		Min	Mean	Max	Min	Mean	Max
VOLCFNET	m3/ha	1.0	82.4	328.7	0.2	87.0	378.3
GROWCFGS	m3/ha/year	0.2	6.0	26.4	-6.3	3.3	18.4
REMVCFGS	m3/ha	0.6	9.5	20.9	0.8	10.8	32.1

Table 3. Timber net volume (VOLCFNET), growth (GROWCFS) and removal (REMVCFGS) for Forest Stewardship Program (FSP) properties and buffers (non-FSP properties) in northwestern Florida

Categories	Units	Forest Stewardship Property			Buffer		
		Min	Mean	Max	Min	Mean	Max
VOLCFNET	m3/ha	20.4	103.6	231.0	0.6	89.9	335.9
GROWCFGS	m3/ha/year	-4.6	1.4	6.1	-4.4	3.9	21.4
REMVCFGS	m3/ha	3.3	4.3	6.7	1.2	10.4	34.7

Table 4. Timber net volume (VOLCFNET), growth (GROWCFGS) and removal (REMVCFGS) Forest Stewardship Program (FSP) properties and buffers (non-FSP properties) in central Florida

Categories	Units	Forest Stewardship Property			Buffer		
		Min	Mean	Max	Min	Mean	Max
VOLCFNET	m3/ha	6.6	89.0	171.4	0.6	162.5	390.0
GROWCFGS	m3/ha/year	1.2	1.8	2.3	17.2	25.5	33.8
REMVCFGS	m3/ha	19.3	19.3	19.3	0.0	0.0	0.0

Table 5. Timber net volume (VOLCFNET), growth (GROWCFGS) and removal (REMVCFGS) for Forest Stewardship Program (FSP) properties and buffers (non-FSP properties) in southern Florida

Categories	Units	Forest Stewardship Property			Buffer		
		Min	Mean	Max	Min	Mean	Max
VOLCFNET	m3/ha	98.7	98.7	98.7	3.7	51.6	99.5
GROWCFGS	m3/ha/year	3.2	3.2	3.2	0.9	0.9	0.9
REMVCFGS	m3/ha	0.0	0.0	0.0	0.0	0.0	0.0

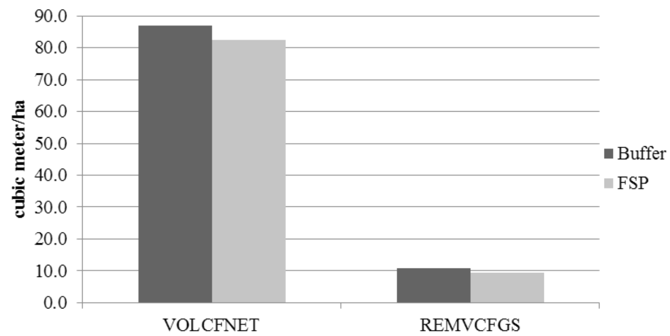

Figure 3. Timber net volume (VOLCFNET) and removal (REMVCFGS) for Forest Stewardship Program (FSP) properties and non-FSP properties (buffers) in northeastern Florida

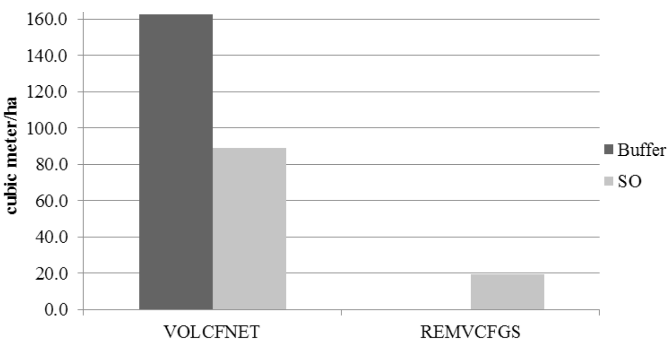

Figure 4. Timber volume (VOLCFNET) and removal (REMVCFGS) for Forest Stewardship Program properties (FSP; SO) and non-FSP (Buffer) in northwestern Florida

InVEST Model Scenarios

The InVest model provided three types of outputs: Total Present Net Economic Value (TPNV), Total Biomass (TBiomass), and Timber Volume (TVolume). As indicated earlier, our results are summarized based on FIA units. A total of 145 timber parcels were analyzed in the northeastern unit and timber harvest area was equal to 12,214 hectares. Both scenarios (1-FSP and 2-Non-FSP) produced the same volume of timber (339,429 m^3) and the TPNV was $10,100,545 for the Non-FSP (scenario 2), which is equivalent to $826 per hectare (Figure 7). In the northwestern unit, 114 timber parcels were identified for the analysis or 7,021.8 hectares of timber harvest area. Both the FSP and non-FSP scenarios produced 291,405 m^3 of timber and the TPNV was higher for the non-FSP Scenario 2 with a total of $6,063,369 and $863 per hectare (Figure 7). In the central unit, an area of 321.6 hectares was harvested in a total of 6 timber parcels. Both the FSP and non-FSP scenarios produced 11,384 m^3 of timber. A total of 3 timber parcels were analyzed in the southern unit and the timber harvested area was 378.7 hectares and both scenarios produced 10,037 m3 of timber. The TPNV was higher for scenario 2 with a total of $200,801, or $530 per hectare (Figure 7).

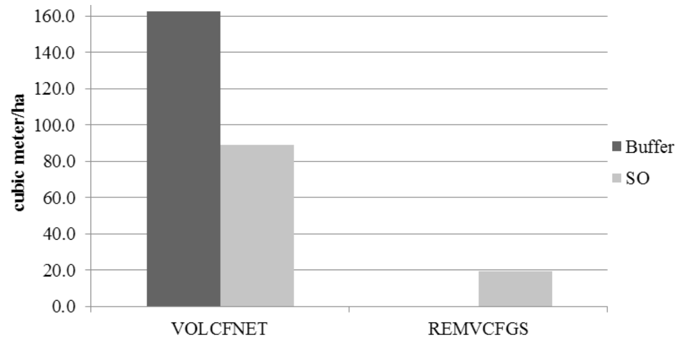

Figure 5. Timber net volume (VOLCFNET), and removal (REMVCFGS) for Forest Stewardship Properties (FSP; SO) and non-FSPs (buffer) in central Florida

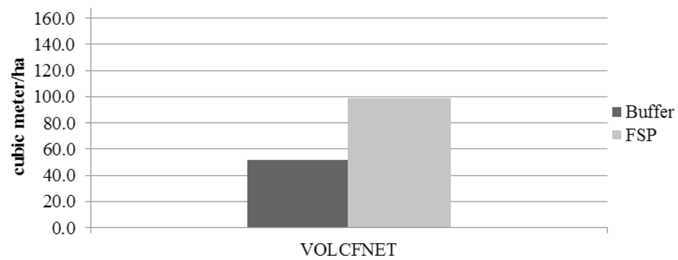

Figure 6. Timber net volume (VOLCFNET) for Forest Stewardship Program (FSP) properties and non-FSP properties (buffers) in southern Florida

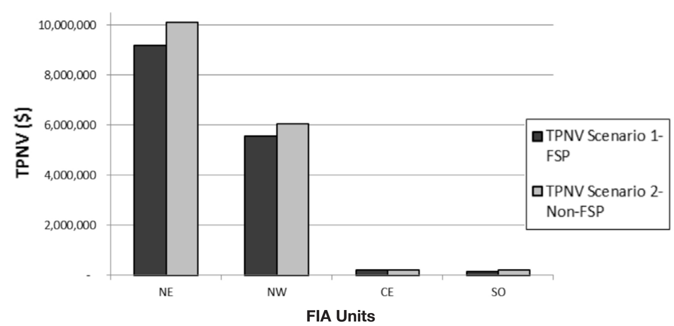

Figure 7. Total Net Present Economic Value (TPNV) of timber for northeastern (NE), northwestern (NW), central (CE) and southern (SO) FIA units

Discussion and Conclusion

The timber net volume for FSP properties in the four FIA units ranged from 82.3 to 103.6 cubic meter/ha, and for non-FSPs ranged from 52.6 to 162.4 cubic meter/ha. Overall higher timber volumes were simulated in non-FSP. However, in the northwestern and southern Florida FIA units, FSPs had higher volumes than non-FSP properties. The GROWCFGS was greater for FSPs in northeastern and southern Florida and ranged from 1.4 to 6 m^3/ha/year and for non-FSP from 0.9 to 25. m^3/ha/year. The REMVCFGS was greater on FSPs in central Florida and non-FSPs in northeastern and northwestern Florida.

Modeling results for estimated TPNV per hectare estimates are based on the best available information and personal communications with FSP coordinators at the University of Florida and Florida Forest Service. The timber volume[1] results in scenarios 1 and 2 produced the same volume of timber across the four FIA units. This is counter to the common management practice of thinning to increase growth. However, we found no evidence that the basal area of thinned plots will exceed the basal area of un-thinned plots (Assmann 1970; Hamilton 1976; Pienaar 1979, cited by Hasenauer et al. 1997). Similarly, according to Sabatia et al. (2010), the total aboveground standing biomass is generally higher in unthinned stands. Although the total biomass or basal area of an unthinned stand is higher, if a stand is managed for saw timber, thinning will reduce competition and increase the growth of desired saw timber trees. The largest revenue (Net Present Economic Value [2]) was achieved for scenario 2 (non-FSP criteria). This result is likely due to this type of management objective which results in a greater amount of timber biomass being available for final harvest at a higher prices. Siry (2002) mentions that intensified forest management generated positive and attractive financial returns that are characterized in scenario 1 in our analysis (less management with only one thinning treatment).

A common limitation with the use of FIA data are that publically available plot coordinates are approximately +/- 1 mile from their true coordinates for annual inventory data, so most plots are within +/- ½ mile (Woudenberg et al. 2010). However, this limitation was overcome by using georeferenced data provided by the USDA Forest Service FIA personnel (Sam Lambert, USDA Forest Service, personal communication, 2011). An additional InVEST timber model limitation is that all the parameters are considered constant over time and the model assumes that the percentage of forest, the mass of timber harvested at each harvest period, harvesting frequency and harvest related prices/costs remain constant in each timber parcel over the user-defined time period. In reality, each of these variables can change from year to year (Tallis et al. 2011). In our analysis, however, these limitations should not have an effect as our scenarios consider only a single harvest period. Finally, even though the timber harvest information is part of the Forest Management Plan of the FSP properties, there is no easy way to access that information. Therefore scenarios were created to compensate for this lack of this data.

According to these results, there are no significant differences between a FSP and a non-FSP scenario, and might be a result of the only difference in management between both being the use of thinning. However, it is important to emphasize that FSP promotes multiple-use forest management. A typical FMP promotes conservation of soil and water, protection of wildlife habitat and wetlands, timber production, livestock grazing, recreation and beauty (Duryea et al. 1992). This means that ecosystem service value provided by such management schemes is high due to the co-benefits received for all the services they provide.

[1]TVolume: it is the total volume (m^3) of harvested timber removed from each timber parcel from the T years (Tallis et al. 2011).

[2]TPNV: it is the net present economic value of timber in terms of the user-defined currency. TNPV includes the revenue that will be generated from selling all timber harvested in the T years.

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Appendix 1.

Data needs for the InVEST timber production model (Adapted from Tallis et al, 2011)

#	Parameters	Description	Units	Value	Source
			GIS Layer		
1	Timber parcels (shapefile)	Forest stands that will be harvested.			Florida Fish and Wildlife Conservation Commission
			Tabular data		
2	*Production table*				
2.1	Parcel area	Area of the timber parcel that will be harvested.	Hectares		Christopher Demers, personal communication
2.2	Percentage of harvest	Proportion of timber parcel that is harvested each harvest period.	%	Two harvest methods are considered, (1) the clear-cutting method with a residual harvest of 25% and (2) the selective method with a 40% of harvested timber.	Duryea et al. 1992 Harrington, 2001 Peckham et al, 2010
2.3	Harvested mass (Harv_mass)	Mass of timber harvested per hectare in each harvest period.	Mg/ha	The mass values by Unit were calculated using the USDA FIA data The Values assigned were NE: 39.7, NW: 41.5, CE: 35.4, and SO: 26.5.	USDA FIA, 2009
2.4	Frequency of harvest	Frequency of harvest periods for each parcel.	Years	1 year	
2.5	Price	Marketplace value of the timber harvested from the parcel.	$/ton	The assigned price was 33 $/ton	Timber Mart-South, 2003-2007.
2.6	Maintenance cost	Annualized cost of maintaining the timber parcel.	$/ha/year	The values were 63 $for scenario 1 – FSP and 55 $for scenario 2 – no FSP.	USDA Forest Service North Central Research Station, 2005. Dickens et al. 2007
2.7	Harvest cost	Cost incurred when harvesting the Harv_mass	$/Harv_mass	The value assigned was 10.23 $/tons	Timber Mart-South, 2007.
2.8	T	Number of years that parcel harvests will be valued.	Years	Only one harvest was realized so the value assigned for T was 1.	
2.9	Immediate harvest	The harvest occurs immediately or not.	YES-NO	Only one harvest was realized, so this means that the harvest occurred in the present year, so the value assigned was "YES".	

Data needs for the InVEST timber production model (Adapted from Tallis et al, 2011) *continued*

#	Parameters	Description	Units	Value	Source
2.10	BCEF	Expansion factor that translates the mass of timber into volume of harvested timber.	Mg of dry timber per m3 of timber	The conversion factor was set as 1	Talis et al, 2011
3	Market discount rate	Reflects society's preference for immediate benefits over future benefits.	%	The value was set equal to 3%	Tallis et al, 2011.

Appendix 2.

Timber Model Parameters-Methods

Timber parcels were identified using the land cover data from the Florida Fish and Wildlife Conservation Commission corresponding to the year 2003. The Pineland land cover was the only forest ecosystem used for the Timber production model. Pinelands were chosen because the majority of the timber production in Florida is for pine species. According to Johnson et al. (2008), softwood species in Florida accounted for an output of 419 million cubic feet in 2005 and hardwood species output was 46 million cubic feet. Slash and longleaf pine species group provided more timber volume than any other softwood species group.

Pinelands within FSP properties were extracted from the land cover layer using the ArcGIS software. Only timber parcels greater or equal to 25 hectares in area are considered in the analysis. The number of properties analyzed is shown in Table 1 organized by FIA units.

Harvested mass was determined using the USDA FIA data. The FIA data was downloaded from the USDA Forest Service webpage (http://apps.fs.fed.us/fiadb-downloads/datamart.html). The data has information on the dominant species in each plot. We selected and extracted pine species data only. The FIA database provided tree-level information about the "dry biomass in the merchantable bole"[3] (Drybio_bole), this value was used to calculate the reference mass value for each FIA unit (NE-NW-CE-SO). This is a per tree value and must be multiplied by the factor Trees per acre unadjusted (TPA_UNADJ)[4] to obtain per acre information (Woudenberg et al, 2010).

All tree values for the same plot were summed to get the Drybio_bole for all the plots. The plots measured in the period from 2002-2007 (cycle 8) were considered. Once plot information is prepared, the values for the same FIA unit (NE-NW-CE-SO) were averaged to get the final value for each FIA unit.

The average biomass is slightly different for each FIA unit as shown in Table 2. These average values were used as a reference mass value per hectare for the pinelands (the amount of biomass available per hectare by FIA unit). In doing so, the reference merchantable dry biomass value is always the same for a FIA unit, but the percentage of timber harvested will differ depending on the priority of timber as a management objective. If a thinning method was applied, the thinned biomass needs to be subtracted from the whole amount of timber. Usually 30% is extracted in the first thinning process (Hasenauer et al. 1997).

[3] The ovendry biomass (pounds) in the merchantable bole of timber species [trees where diameter is measured at breast height DBH)] greater than or equal to 5 inches in diameter.

[4] Trees per acre unadjusted. The number of seedlings per acre that the seedling count theoretically represents based on the sample design.

Table 1. Total timber parcels and Forest Stewardship Program (FSP) landowners with more than 25 ha parcels of pineland timber in the 4 USDA Forest Service Forest Inventory and Analysis (FIA) units in Florida

FIA Unit	FSP landowners[a]	Total possible timber parcels	Total FSP area (ha)
Northeastern	125	145	51,081
Northwestern	108	114	21,111
Central	6	6	2,956
Southern	3	3	1,074

[a]Many FSP landowners have more than one property

Table 2. Regional average dry biomass in the merchantable bole (Mg/ha) in the 4 USDA Forest Service Forest Inventory and Analysis (FIA) units in Florida

FIA unit	Dry Biomass (Mg/ha)
Northeastern	39.7
Northwestern	41.5
Central	35.4
Southern	26.5

Two harvest methods were considered to estimate the *percentage of harvest* for each scenario (Table 3). The first method is a clear-cut method that consists of 100% of harvest minus the residue (25%).The second method is a selective cutting that harvests 40% of the timber (Peckam et al, 2010). An average *market price* was calculated using the information provided by the Florida Forest Stewardship program based on the Timber Mart-South (TMS, 2003). Market prices between 2003 and 2007 were considered. *Maintenance cost* for replanting, fire protection, taxes and forest management treatment was considered for the two scenarios, while thinning cost was considered only for FSP Scenario. These costs were obtained from Dickens et al (2007) and the USDA Forest Service North Central Research Station (2005). Model parameter *Harvest cost* was obtained from Timber Mart-South values (TMS, 2007) and was kept constant for both scenarios to facilitate scenario development. However, harvests costs are usually included in stumpage price, thus the cost difference between stumpage and TMS gate prices might have better reflected actual harvesting costs. *The expansion factor (BCEF)* was set equal to 1 (Tallis et al. 2011). The *Market discount rate* was defined as 3% per year, which is one of the rates recommended by the US government for environmental projects (Tallis et al. 2011).

Literature Cited

See Managed Timber Production Report.

Appendix 3.

Scenarios for the Timber production model

<table>
<tr><th>Properties with prioritized Timber Objective (Obj.)</th><th>% harvested</th><th>Frequency and T (years)</th><th colspan="2">Harvest mass (Mg/ha)</th><th>Immediate</th><th>Area (ha)</th><th colspan="2">Annual Cost ($/ha/year)</th><th>Harvest cost ($/ton)</th><th>Price ($/ ton)</th></tr>
<tr><td colspan="11">SCENARIO 1 – FOREST STEWARDSHIP PROGRAM CRITERIA</td></tr>
<tr><td colspan="11">SC1.1 – THINNING</td></tr>
<tr><td>First obj.</td><td>75
(25% residue)</td><td>1</td><td>NE
NW
CE
SO</td><td>11.91
12.45
10.62
7.95</td><td>YES</td><td>>= 25</td><td></td><td>0</td><td>124 $/ ha</td><td>27</td></tr>
<tr><td>Second and third obj.</td><td>40
(60% residue)</td><td>1</td><td>NE
NW
CE
SO</td><td>27.79
29.05
24.78
18.55</td><td>YES</td><td>>= 25</td><td></td><td>0</td><td>124 $/ ha</td><td>27</td></tr>
<tr><td colspan="11">SC1.2 – FINAL HARVEST</td></tr>
<tr><td>First obj.</td><td>75
(25% residue)</td><td>1</td><td>NE
NW
CE
SO</td><td>27.79
29.05
24.78
18.55</td><td>YES</td><td>>= 25</td><td>Replanting
Fire protection
Taxes
Management
TOTAL</td><td>33
5
12
5
55</td><td>10.23 $/ton</td><td>33</td></tr>
</table>

Scenarios for the Timber production model *continued*

Properties with prioritized Timber Objective (Obj.)	% harvested	Frequency and T (years)	Harvest mass (Mg/ha)		Immediate	Area (ha)	Annual Cost ($/ha/year)		Harvest cost ($/ton)	Price ($/ ton)
Second and Third obj.	40 (60% residue)	1	NE	27.79	YES	>= 25	Replanting	33	10.23 $/ton	33
			NW	29.05			Fire protection	5		
							Taxes	12		
			CE	24.78			Management	5		
			SO	18.55			TOTAL	55		
First obj.	75 (25% residue)	1	NE	39.7	YES	>= 25	Replanting	33	10.23	33
			NW	41.5			Fire protection	5		
			CE	35.4			Taxes	12		
							Management	5		
			SO	26.5			TOTAL	55		
Second and Third obj.	40 (60% residue)	1	NE	39.7	YES	>= 25	Replanting	33	10.23	33
			NW	41.5			Fire protection	5		
			CE	35.4			Taxes	12		
							Management	5		
			SO	26.5			TOTAL	55		
							Taxes	12		
							Management	5		
							TOTAL	22		

Ne=Northeast; NW=Northwest; CE=Central; SO=South

Species Conservation Value of Non-Industrial Private Forestlands

Dr. Timm Kroeger, The Nature Conservancy
(with assistance from Shelley Johnson, Josh Horn, University of Florida)

Introduction

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 (an additional unit of) the good or service, or the minimum amount he or she is willing to accept as compensation in order to give up (the next unit of) the good or service. Willingness to pay (WTP) is the preferred measure of value in economics because it is considered to be the conceptually correct value indicator, relying as it does on an assessment of value by the actual individuals whose values are being measured (Arrow et al. 1996).[1]

The total economic value of a species is the sum of the improvements in people's well-being that results from the full range of uses the species supports. These uses represent the ecosystem services provided by the species. When cataloging these services for the purpose of economic valuation, it is generally helpful to define them in final, benefit-specific terms, as components of nature that are directly consumed, enjoyed or otherwise used to produce human well-being in order to avoid double-counting (Boyd and Banzhaf 2007). For example, the benefits provided by gray wolves (*Canis lupus*) in North America comprise recreation (wolf viewing and hunting to the extent the latter occurs), research and education, spiritual and religious, and non-use (often also referred to as passive use) values. In addition to these final services through which they directly benefit human well-being, wolves also provide intermediate services that support other, directly-used, final ecosystem services. For example, through predation, wolves control herbivore populations (Ripple and Beschta 2004), limiting the widespread overbrowsing of riparian vegetation. This in turn maintains habitat quality for game fish like trout, scenic views of largely undisturbed landscapes, and other services directly consumed by people. Because these intermediate services provided by wolves ultimately benefit people, they also carry economic value. However, their value is embodied in the value of the associated final services – trout available for sport fishing, scenic landscapes for viewing, and so on. Because final services benefit people directly, they generally are easier to value than the intermediate services that support the final services. Also, if the value of several ecosystem components is estimated – e.g., wolves, trout, elk, water for livestock feeding and home consumption, timber production – then a focus on final ecosystem services avoids the problem of double-counting.[2]

Many species support a variety of benefits. Table 1 provides examples of such final services and the specific benefits they yield, and of selected animal species providing the respective services.

[1] Using WTP to guide policy-making is problematic from an equity perspective as it can lead to decisions that exacerbate existing inequities. By definition, all else equal, a wealthier neighborhood will have a higher WTP for a given good, say, a neighborhood park, even if the two neighborhoods had the same number of residents and each resident in the two areas received the same amount of physical, spiritual, emotional or other pleasure from the park, simply because ability to pay constrains WTP and increases with income. Thus, using WTP as the sole allocation factor driving public investment decisions will result in a systematic bias in favor of wealthier areas.

[2] If one estimated both the control of herbivores by wolves (an intermediate service of wolves) in the form of the contribution this service makes to associated water quality and scenic benefits, and also separately estimated the value of trout fishing and scenic views, the total value of trout fishing and scenic views would be overestimated, because the value of both the inputs and the final outputs would be counted in such an analysis.

Table 1. Examples of ecosystem services and associated benefits provided by wild animal species

Benefit	Final ecosystem service	Species providing service
Wildlife-associated recreation use (fishing, hunting, viewing)	Species populations	"Charismatic" species
Commercial animal harvests[a]	Species populations in specific places	Fish and shellfish; mammals; reptiles birds
Subsistence animal harvests	Species populations in specific places	Fish and shellfish; mammals; reptiles; birds
Reduced human morbidity or mortality: medicines	Species populations	Potentially any species[b]
Reduced human morbidity and mortality: coastal flooding	Structures built by species (reefs) in particular locations	Oysters, corals
Reduced property damage: coastal flooding	Structures built by species (reefs) in particular locations	Oysters, corals
Improved crop and farmed animal harvests: plant pest control	Species populations (gene pool)	Animals preying on plant pests
Improved farmed animal harvests: disease control	Species populations (gene pool)	Wild relatives of domesticated species
Research and education	Individuals or populations in particular locations	Any
Improved aesthetics, recreation	Water quality • swimming (reduced turbidity); • larger cold water game fish populations (reduced temperature);	Oysters (turbidity); wolves (temperature)
Existence, stewardship, bequest (non-use) values	Species populations	Primarily "charismatic" species, but potentially any species
Spiritual and religious values	Species populations	Any, but often charismatic species

[a]Includes farming operations supported by infusion of genes from wild individuals.

[b]For examples, see Chivian and Bernstein (2008).

In economic terms, the benefits a species provides to humans can carry both use and non-use values. Use values refer to increases in well-being people derive from the direct interaction with species (direct use value), or from retaining the opportunity for future direct interaction (option value). This direct interaction can be consumptive in nature, as in the case of hunting, trapping or fishing or non-consumptive as in the case of wildlife viewing or photography. By contrast, non-use values, also referred to as passive use values, are not associated with any direct interaction with the species but rather are caused by a person's appreciating a particular species' existence (existence value) or its conservation for future generations (stewardship and bequest values; Prato 1998). Use and non-use values together make up the total economic value (TEV) of a species (Figure 1).

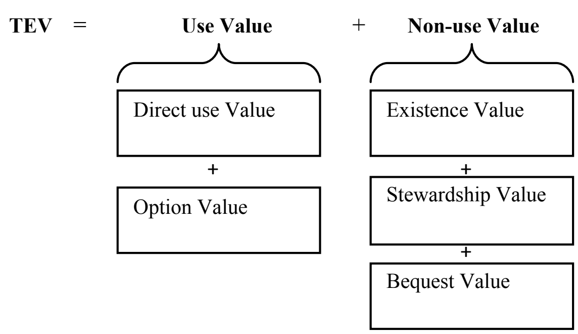

Figure 1. Composition of the total economic value (TEV) of a species

The concept of non-use value and the fact that this value constitutes an integral part of the total economic value of a resource have long been formally recognized in economics (Weisbrod 1964; Krutilla 1967; Freeman 2003). Non-use values have been documented and quantified for over 30 threatened, endangered or rare species in the US alone (Appendix 1), as well as for all major terrestrial vegetation types, several marine habitats, and many unique landscapes (Kroeger and Manalo 2006). In addition to this evidence from scientific surveys, the fact that large numbers of people make voluntary contributions to organizations that support the conservation of threatened, endangered or rare species that most of them never will interact with in the wild and that people invest time and other scarce resources to support conservation actions and laws further demonstrate that many people assign real economic value to the conservation of species that is separate from and additional to any potential direct use.[3]

Because non-uses do not generate market activity, there is no spending information that can be observed and used to estimate the value people assign to a particular non-use, such as the preservation of a species.[4] Rather, the non-use values can only be estimated through what are known as stated preference approaches. In the most common of these approaches, contingent valuation (CV), a hypothetical market for a particular resource, is constructed by presenting individuals with a particular change in the quantity or quality of the resource, and then asking them directly how much they would be willing to pay to make that change happen (in case of a positive change) or to prevent it (in case of a negative change), or how much they would require in compensation to accept the change (in case of a negative change). In a less- often-used stated preference technique, conjoint analysis (e.g., Milon et al. 1999), respondents are not directly asked to state their WTP or willingness to accept (WTA) for a hypothetical change. Rather, they are presented with and then asked to choose among different options, each of which represents a bundle of particular resource quantity and quality changes and project costs. Respondent's WTP or WTA are then estimated through statistical analysis of their choices.

The construction of hypothetical scenarios that yield accurate and logically consistent answers from respondents is a complex undertaking because there are several factors that can result in biased responses that do not express respondents true WTP (e.g., Diamond and Hausman 1994;

[3] The motivations for valuing the environment or its components vary widely among individuals, and may include (1) spiritual or ethical causes, such as a belief in the inherent right of other species or their habitats to exist, and the responsibility to respect that right; (2) sympathy for or empathy with other living creatures; (3) altruism towards plants and animals; (4) a recognition that species form part of the web of life and, functioning as environmental linkages, and hence maintaining the functioning of specific ecosystems; (5) the fact that an area provides habitat for a variety of endangered, threatened, and rare species; (6) an appreciation of a species' or landscape's beauty or uniqueness; and (7) bequest goals (Bishop and Heberlein, 1984; Boyle and Bishop, 1987; Madariaga and McConnell, 1987; Sagoff, 1988; Harpman et al. 1994).

[4] The one exception to this are contributions to conservation organizations, which are reflected in market transactions. However, because most environmental organizations are engaged in a variety of issues beyond conservation of threatened or endangered species, it is in most cases impossible to use contributions to such organizations in order to develop reliable estimates of passive use values of their supporters.

Stevens et al. 1991, 1993). In a thorough review of the issue, a "blue ribbon" panel of influential economists convened by NOAA (Arrow et al. 1993) established a set of guidelines for the use of CV methods and concluded that CV can provide a valid economic measure of value associated with resources people do not actually use but whose existence they may nevertheless value. Several comprehensive literature reviews (Carson et al. 1996, 2001) found that while good CV study design is a significant challenge, there is broad evidence that CV estimates in general are consistent with economic theory and similar to their revealed preference counterparts.

Importantly, non-use values have been recognized as legitimate components of the economic value of natural resources by the courts (US Court of Appeals, 1989) and by legislation (US Department of Commerce, 1994; US Department of the Interior, 1994). It is important to point out that all economic values are assigned values and thus are purely anthropocentric by design. It can be argued on philosophical grounds that all living things, and perhaps even ecosystems, also have *intrinsic* values, that is, they are valuable independently of their importance for, or usefulness or appeal to, humans (e.g., see Kneese and Schultze 1985; Sagoff 1988). It is conceptually impossible to assign an economic value to this intrinsic component, because economic values necessarily are based on human values and perceptions.[5]

Assigned values in turn are a function of people's held values, that is, the social ordering principles society regards as desirable, such as fairness, freedom, or legal or political equality. In addition, assigned values also depend on the relative scarcity of a resource and its substitutes and complements, of people's knowledge about the resource, and of the particular perspective from which a person conducts the valuation.[6] Because held values and other determinants of assigned values vary among individuals and often vary over time, it is important to realize that economic values are always context-specific. For this same reason, it is generally accepted among economists that individuals are the best judges of the value they receive from a good or service and thus that the best source of WTP data are the actual individuals whose values are being measured (Arrow et al. 1996).

While this is undoubtedly correct, the validity of WTP estimates crucially depends on people not being asked to value ecosystem components or functions with which they are unfamiliar or whose contribution to their well-being is not immediately clear to them (Vatn and Bromley 1994).[7] However, this problem does not apply to the ecosystem services analyzed in this study – populations of specific animal species – because people generally are reasonably familiar with the species for which their WTP was elicited in the studies on which our analysis is based.

Methods

The non-use value literature has identified a number of variables that have a significant effect on people's WTP for threatened and endangered (T&E) species conservation. While most of these variables are (binary) indicators that reflect specific species (e.g., mammal, fish, bird), elicitation (e.g., lump sum vs. annual payment, type of payment vehicle, entity in charge of program administration, close-ended vs. dichotomous choice vs. payment card, contingent valuation vs. conjoint analysis) or respondent characteristics (e.g., visitor vs. local resident), the size of the change in a species' population is the key continuous variable driving WTP (Richardson and Loomis 2009).

Thus, the first step in estimating the non-use value that stewardship lands generate consists in the quantification of the size of the avoided species population reductions that is brought about by the enrollment of those lands in the stewardship program. Having identified this change, original valuation study or benefits transfer can be performed to estimate people's WTP for these avoided population reductions. The design and implementation of an original valuation study is beyond the scope of this project. Instead, we apply benefit transfer to generate estimates of the value Floridians assign to the avoided losses in selected species populations that result from the Forest Land Stewardship Program. Benefit transfer is the application of existing valuation estimates from (an) original study site(s) to a new

[5] Heal (1997) suggests that this intrinsic value could potentially be incorporated into decision making by interpreting it as placing a constraint on society's economic activities.

[6] Studies show that people's choices and thus assigned values depend on whether they evaluate a given issue as a consumer or as a member of society. These two perspectives reconcile observed behaviors that appear contradictory when viewed from the perspective of utility maximization based on consumption (Sagoff 1988; Brouwer et al. 1999; Kontogianni et al. 2004).

[7] In addition, in cases where individuals assign values to future impacts, these values may not be rational and often are not compatible with society's best interests (Caplin and Leahy 2001).

site for which valuation estimates are sought but where an original study is not feasible due to lack of time or cost constraints (Bergstrom and De Civita 1999).

In the remainder of this section, we present literature findings from the US on people's WTP for species conservation, followed by estimates of the avoided losses in statewide populations of selected species found on FSP lands and estimates of the non-use value of these avoided losses based on three different valuation approaches.

Literature review of economic valuation studies for threatened or endangered species, species of state concern, and other species of interest found on FSP lands

Threatened or endangered (T&E), rare, State Special Concern species (SSC), and additional species of interest present on FSP lands were identified, and their potential habitat acreage in Florida and on FSP lands and was calculated using GIS analysis (Appendix 2). Stewardship lands contain habitat for seven species listed as endangered under the ESA and one candidate species; habitat for 13 species listed as threatened under the ESA or Florida Endangered and Threatened Species Act; and habitat for 15 species of State Special Concern in Florida. We conducted a literature search to locate economic valuation studies for threatened, endangered, rare, or charismatic species found on FSP lands. A recent study (Richardson and Loomis 2009) compiled most of the published studies and reports that estimate WTP for individual species or groups of species. We queried Web of Science, JSTOR, various economic databases, ProQuest Dissertations and Theses, Worldcat Theses and Dissertations, as well as U.S. Forest Service and U.S. Fish & Wildlife Service databases using combinations of "willingness-to-pay", "WTP", "contingent valuation", "valuation" and "wildlife", "species", "animal", "endangered", "rare", or "threatened". All located articles were also forward and back tracked using Web of Science to identify potentially relevant citations. The willingness-to-pay values extracted from studies not included in Richardson and Loomis (2009) were converted to 2006 U.S. dollars (the base year of the WTP estimates used in Richardson and Loomis) using the Consumer Price Index (Appendix 1). None of the new studies we located focused on species found on FSP lands.

Based on the literature search, we identified two T&E, SSC, or rare species found on FSP lands for which published willingness to pay (WTP) estimates are available: the red cockaded woodpecker and the bald eagle. Because of the availability of published WTP estimates, these two species are included in our analysis. Three further species present on FSP lands were identified for inclusion in our analysis due to their high public awareness factor. These are the Florida black bear, the gopher tortoise and the Florida scrub-jay. No WTP studies exist for these species. While WTP estimates are available for the grizzly bear (USFWS, 2000a) and the loggerhead sea turtle (Whitehead, 1992), these species are sufficiently different in terms of their public perception to make questionable their use as valid sources for benefit transfer to the Florida Black bear and gopher tortoise, respectively. The GIS analysis indicates that the potential habitat of these species that is located on stewardship lands in all cases accounts for less than 1 percent of their potential habitat in the state (Appendix 2).

Predictions of expected avoided losses in the populations of selected charismatic species due to FSP lands

The non-use value of stewardship lands in species conservation depends on the extent to which the enrollment of lands in the stewardship program improves habitat quality and quantity for particular species and, ultimately, the effect these improvements have on the size of the populations of these species in the state.

Quantifying this value requires information on the current and future population sizes of the species in question both on and off stewardship lands. It also requires estimates of how those populations would have changed in the absence of the stewardship program. Detailed understanding of the species' biology and population dynamics, spatially explicit, high-resolution information on land use or land cover change and its drivers, as well as sophisticated predictive spatial analysis tools that can quantify the impact of habitat changes on a species' population are required to construct such expected actual and counterfactual population scenarios. It is beyond the scope of this analysis to carry out such detailed analyses of species populations for the base case ("with stewardship program") or counterfactual ("without stewardship program") scenarios. Rather, we rely on expert judgment to generate estimates of the avoided reductions in the populations of our five focal species that are achieved through the stewardship program. Expert elicitation is a widely applied approach that combines empirical data with informed judgment to generate quantitative estimates of specific quantities in the face of data gaps (US EPA, 2011). Expert elicitation can employ a variety of methods. In this study we used the Delphi method, a group process that allows participating experts to refine their original estimates through structured deliberation with each other (ibid.).

We identified two experts each for the gopher tortoise and the Florida black bear, and three each for the Florida scrub-jay, red-cockaded woodpecker and bald eagle. All experts are biologists or managers with the Florida Fish and Wildlife Commission. After the experts were contacted and agreed to participate, each received by e-mail a brief description of the study together with the relevant map of potential habitat of the particular species and the percentage of statewide potential habitat that is located on stewardship lands, and the request to indicate their best estimate of the potential loss in the species' total Florida population that might result from the loss of its habitat on stewardship lands, taking into account habitat quality, likelihood of fragmentation of non-stewardship lands, and any other factor they considered relevant to the assessment. Experts also were asked to indicate their broad level of confidence in their estimates (low, moderate, high) as well as the main reasons for their confidence or lack thereof. (See Appendix 3 for the text used in the questionnaire). Experts for a particular species generally consulted with each other in the development of their estimates.

Perhaps not surprisingly given the very small percentages of our five focus species' statewide habitats that are found on stewardship lands, the latter were thought to support the populations of these five species only marginally. Specifically, in the absence of stewardship lands, experts indicated they thought the statewide population of the bald eagle would decline by less than 3%; that of the red-cockaded woodpecker by zero to 5%; and that of the Florida scrub-jay by 1% to 1-3%. The impact of stewardship lands on the population was thought to be not directly measurable for the Florida black bear, and negligible for the gopher tortoise (Table 2).

Table 2. Expert assessment of potential loss in Florida population of 5 species avoided through stewardship lands

Expert #	Species and % pop. decline	Confidence	Notes on coordination	Reason for answer
				Florida Black Bear
1	"no direct measurable effect"	High	cc'd expert 2 on response	There is an exceedingly small overlap of bear habitat with FSL. Also, given the small (by bear standards) size of the FSL parcels, even their collective importance to bears is negligible. Given the current methodologies we have to choose from to estimate bear numbers, the number of bears lost due to the loss of these lands is not measurable (i.e. it would be within our Confidence Interval). However, many of these parcels fall within potential or actual regional scale wildlife corridors that are important for bear conservation. Maintaining these corridors will promote genetic interchange between bear populations and provide habitat for dispersing animals. Corridors are important for bears in Florida and will become more so as Florida loses natural landscape. The FSL parcels between Eglin AFB and Apalachicola NF and between Apalachicola NF and Osceola NF would likely be important to establish and/or maintain these corridors.
2	no reply			
				Florida Scrub-Jay
3	1%	low	conferred with expert 4	Sources of uncertainty include: (1) uncertainty in the boundaries of Forest Stewardship lands due to the coarse grain of the image, and (2) uncertainty regarding the current number of scrub-jays remaining on some private lands. The estimate reflects the loss of habitat on Forest Stewardship lands as well as loss of connectivity among patches of scrub-jay habitat.
4	1%	low	conferred with expert 3	

Table 2. Expert assessment of potential loss in Florida population of 5 species avoided through stewardship lands *continued*

Expert #	Species and % pop. decline	Confidence	Notes on coordination	Reason for answer
5	1-3%	moderate		It is difficult to be 100% certain at the resolution of the map, and some of those properties might be well-managed and currently occupied by scrub-jays, but I would need a higher resolution map to know which properties actually have scrub or scrub-jays.
Red-cockaded Woodpecker				
6	5%	low-moderate	independent, offered chance to revise, declined	Many Forest Stewardship landowners don't manage for longer timber rotations to provide the older (50+ years) trees preferred by RCWs, which accounts for the low impact loss of Stewardship lands would have on RCS range.
7	"negligible"		conferred with expert 8	The vast majority of RCWs are on public conservation lands in Florida.
8	"negligible"		conferred with expert 7	The vast majority of RCWs are on public conservation lands in Florida.
Bald Eagle				
9	Not Available		deferred response to expert 11	
10	Not Available		deferred response to expert 11	
11	2.6%	high	conferred with expert 9 and 10	The loss of stewardship lands could potentially affect 59 eagle nesting territories (about 2.6 percent of documented territories are within 1 mile of a FSP). It will directly affect 12 nesting territories (about 0.5 percent of documented territories are on FSP lands). I am fairly confident with the above assessment (95%) but I am not sure about the time frame you are focusing on. Keep in mind that as adjacent lands are converted (in response to climate change) the FSP lands with available habitat may become more important to nesting eagles.
Gopher Tortoise				
12	"cannot give a meaningful numerical estimate of the impact"		conferred with expert 13	Gopher tortoises are significantly depleted and in many cases, no longer exist on many of the FSL. This makes it even more difficult to assess a potential impact or loss (i.e., if there are only a few or no gopher tortoises on these lands, then the loss of the land would not affect the entire population). In areas with GT, losing those populations, even as fragmented as that area is by agriculture, wouldn't be a good thing. Still, the overall impact to the state gopher tortoise population caused by a <1% loss of potential habitat on stewardship lands would hardly be devastating.
13	"cannot give a meaningful numerical estimate of the impact"		conferred with expert 12	Gopher tortoises are significantly depleted and in many cases, no longer exist on many of the FSL. This makes it even more difficult to assess a potential impact or loss (i.e., if there are only a few or no gopher tortoises on these lands, then the loss of the land would not affect the entire population). In areas with GT, losing those populations, even as fragmented as that area is by agriculture, wouldn't be a good thing. Still, the overall impact to the state gopher tortoise population caused by a <1% loss of potential habitat on stewardship lands would hardly be devastating.

Estimates of the non-use value of avoided reductions in selected species populations

We applied three benefit transfer approaches in order to develop non-use value estimates for our five study species. For the bald eagle and red-cockaded woodpecker, we applied point value transfer of existing literature estimates for these species, adjusting WTP estimates for differences in household income and size of species population changes between the study sites and our policy site. In a second benefit transfer approach, we use a meta-analysis based WTP function whose variables we set to the levels appropriate to our study site. We use this function to generate WTP estimates for all five of our study species. Finally, we employ a third and novel approach that relies on the observation that spending on species protection is a function in part of the value people place on that species, with higher-valued species receiving higher levels of spending on their conservation. Relative differences in public conservation spending on a species, which is driven partly by people's perception of and attitudes toward the species, thus may serve as an indicator – though likely not an unbiased one – of the relative value people place on the conservation of various species. We compared public spending on each of the three species for which no literature WTP estimates exist, with public spending on the bald eagle and the red-cockaded woodpecker, for which WTP estimates are available, and then used the expenditure ratios to develop WTP estimates for the three species by scaling the WTP estimates for bald eagle and red-cockaded woodpecker.

Approach No. 1: Value transfer based on literature WTP estimates

For the bald eagle and the red-cockaded woodpecker, point value transfer of literature WTP estimates can be used to derive WTP estimates for the population changes in those species expected to result from the Forest Stewardship Program. Table 3 shows the WTP estimates from these studies together with variables identified in the literature as being significant explanatory factors of WTP for species protection.

Table 3. Literature WTP estimates and study characteristics for the bald eagle and red-cockaded woodpecker

	Type of change	Size of change	WTP (2006 $)		Population surveyed	Survey WTP format
			Annual	Lump sum		
Bald eagle						
Boyle & Bishop (1987)	Avoided loss	100%	$21.21		WI households	DC
Stevens et al. (1991)	Avoided loss	100%	$31.85		New England households	OE
	Avoided loss	100%	$45.21			DC
Swanson (1993)	Gain	300%		$349.69	WA visitors	DC
	Gain	300%		$244.94		OE
R-C woodpecker						
Reaves et al. (1999)	Increased chance of survival[a]	49%	$14.69		SC and US households	OE
		49%	$20.46			DC
		49%	$13.14			PC

Note: DC = dichotomous choice; OE = open-ended, and PC = payment card. WI – Wisconsin; WA= Washington; SC = South Carolina; US = United States

[a]Respondents were asked to state their WTP for an increase in the likelihood of R-C woodpecker survival from 50% to 99%.

Before adjusting the literature estimates for our purposes, the obvious question arises as to which of the five WTP estimates for bald eagle constitutes the most valid source for our transfer. All things being equal, WTP of visitors for species population increases has been found to be higher than that of local households (Richardson and Loomis 2009), presumably in part due to the fact that average income of visitors in the literature exceeds that of local residents, and because the visitors intercepted in the surveys often specifically came to the area for recreation purposes, so differences in preferences for wildlife, or in the strength of these preferences, may be a factor as well.[8] Our primary interest in this study is in Florida residents' WTP, thus making the household WTP estimates for bald eagle conservation more suitable than estimates from visitor surveys. Both of the local resident populations surveyed in the literature (Wisconsin in Boyle and Bishop [1987] and New England in Stevens et al. [1991]) are likely to differ in some WTP relevant characteristics from our study area (e.g., income, preferences for species conservation) – as will the Washington state visitors surveyed by Swanson (1993) – and it is not clear which of the two is a better match.

Unlike the other two studies, Swanson's (1993) WTP estimates of Washington state visitors are expressed in the form of lump sum payments, which, all things being equal, should yield statistically different (higher) estimates (Richardson and Loomis 2009). However, given that respondents likely employ a time horizon that is finite and likely only spans one or two decades when asked about how much they would be willing to pay per year for an avoided reduction in a species' population or for an increase in the population, Swanson's WTP estimates are very similar to the lump sum estimates from the other studies for reasonable values for implicit discount rates. For these reasons, we use the low ($21.21) and high ($45.21) estimates of annual WTP for reduction in the bald eagle population as the basis for our benefit transfer.

Because the literature generally shows that the size of population change has a significant impact on WTP (Richardson and Loomis 2009), these low and high estimates need to be adjusted for the differences in the size of the population changes examined in Boyle and Bishop (1987) and Stevens et al. (1991) and our study context, respectively. In its simplest form, this scaling could use the ratios of population changes in the two studies (100%) and in our study area. Two important questions arise in this context: (1) Does the WTP function for population increases exhibit a threshold below which individuals deem population changes irrelevant to the conservation of the species and thus without value, resulting in a WTP of zero for any increase below that threshold? and (2) Is WTP proportional to the size of population change? Economic theory certainly suggests that marginal WTP should decline for successive increments in population increases (or avoided losses), but does this hold true in the specific case of endangered species conservation?

With respect to the first question, the limited evidence in the literature does not support the existence of a minimum threshold of species population change below which WTP is zero. For example, Boyle et al. (1994) find that people were willing to pay for the avoided death of 2,000 birds in a population spanning millions. Regarding the second question, literature findings on the relation between WTP and size of population change, or change in environmental goods more broadly, seem to be contradictory. For example, Boyle et al. (1994) find insensitivity of WTP to scope (size of population change), while, in a concurrent study in the same location and using the same questions, Schkade and Payne (1993) confirm sensitivity to scope. Evidence for other environmental goods mirrors these findings (see reviews of the issue in Carson et al. 1997; Bateman et al. 1997; Rollins and Lyke 1998).

However, Rollins and Lyke (1998) reconcile the seemingly contradictory observations in the literature regarding the scope sensitivity of existence values by demonstrating that reported findings are in fact consistent with decreasing marginal WTP. They argue that studies reporting lack of sensitivity to scope simply appear to examine changes located along the inelastic section of the WTP curve where respondent satiation is approached and where the slope therefore is very small. Detection of scope sensitivity in the inelastic section of the curve would require much larger surveys than those conducted by the respective studies. In the empirical study Rollins and Lyke (1998) conduct to test their hypothesis, the authors find a well-behaved WTP curve, and no evidence of a WTP threshold.

The available evidence confirms the assumption that WTP changes non-linearly with the size of the change in a species' population. Richardson and Loomis's (2009)

[8] This in turn may be due to the fact that the rare species found in the areas visited may be entirely absent in their home states, so the scarcity or uniqueness of the resources found in the visited area may also increase the value visitors receive from the species.

meta-analysis of existing WTP studies in the US resulted in a coefficient of less than unity on the *CHANGESIZE* variable (in the full best fit model as well as the reduced models). On the logged models, the coefficient on the *CHANGESIZE* variable can be interpreted as the elasticity of WTP with respect to population change. A positive coefficient of less than unity thus indicates that WTP increases with the size of the population change but does so at a decreasing rate. We use the *CHANGESIZE* coefficient from their best fit logged model (Model 2; their table 7), 0.953, to scale the low and high WTP estimates from the literature to our bald eagle population change. Importantly, avoiding the loss of the first percent of the current population is equivalent to keeping the population at 100% as opposed to 99% of its current level. Thus, the 1% whose loss is avoided is located at the far end of the WTP curve where the elasticity of the curve is very low and thus marginal WTP is very small. Using Richardson and Loomis' (2009) elasticity of WTP with respect to population yields an estimated WTP for the first avoided percent of population loss of $0.014 (low estimate) to $0.024 (high estimate). While these values are very small, it should be recalled that they represent WTP for avoiding a 1% reduction in the size of the current population. Nevertheless, these values do seem to be rather conservative. WTP for an avoided loss of 3% – the likely impact of Forest Stewardship lands on Florida bald eagles according to our expert estimates (Table 2) – would range from $0.045 - $0.074 per household, per year.

It is important to note that by applying Richardson and Loomis' (2009) WTP equation to the very small population changes relevant to our study, we are applying it substantially outside of the range of values over which their function was estimated, which ranged from 33 to 600%. This may be problematic in that the function, including the value of the *CHANGESIZE* coefficient, may lose validity outside of the range of values over which it was derived.

In addition to the explanatory variables identified in Richardson and Loomis (2009), the location of the survey may influence WTP estimates in two ways and therefore is important. First, there may be regional differences in people's attitudes toward and thus WTP for species conservation, due to differences in regional culture. However, likely of higher importance is the fact that income levels may differ between the literature study sites and our site (Florida). Income affects ability to pay and thus willingness to pay, all else equal.[9] To adjust for income differences, we scale the population size-adjusted WTP estimates to our study site (Florida) using the ratios of per-capita incomes. Specifically, the low WTP estimate for the bald eagle, which is for Wisconsin, is multiplied by the ratio of per-capita income in Florida in 2010 and per-capita income in Wisconsin in 1989 (the year closest to the year of that WTP study for which this data is available), while the high WTP estimate for the bald eagle, which is for New England, is multiplied by the ratio of per-capita income in Florida in 2010 and population-weighted mean per-capita income in the six New England states in 1989 (the year Stevens et al.'s WTP study was conducted).[10] The scaled WTP estimates for avoided losses in the bald eagle population of one and three percent, respectively, are shown in Table 4.

Table 4. Low and High annual per-household WTP estimates for bald eagle scaled to stewardship land study context

	WTP estimate, 2006 $[a]	
	Low	High
100% avoided loss	$21.21	$45.21
Scaled to Florida 2010 avg. household income[a]	$35.37	$58.42
Scaled to first 1% of avoided population loss[b]	$0.014	$0.024
Scaled to first 3% of avoided population loss[b]	$0.045	$0.074

Notes: [a]Based on Wisconsin 1989 per-capita incomes of $23,346, population-weighted 1989 mean per-capita income in the six New England states of $30,125, and Florida 2010 per-capita income of $38,929, respectively (all in 2010 $). [b]Assuming an elasticity of WTP with respect to species population change of 0.953 (see text).

For the red-cockaded woodpecker, the only available WTP study (Reaves et al. 1999) estimates WTP for a 49% increase in the chance of survival of the species, from 50% to 99%. It is not obvious how this metric could be translated

[9] For example, Bell et al. (2003) found that WTP of higher-income households for salmon population changes exceeded that of lower-income households in all five communities they studies.

[10] For this calculation, the Wisconsin and New England incomes were adjusted to 2010 prices using the consumer price index.

into *percent avoided loss of species population*, the metric used in this study to quantify species impacts. The likelihood of survival of a species is not necessarily proportional to species population size or habitat quantity. For this reason, we do not attempt to translate Reaves et al.'s (1999) WTP values to our study context. Thus, the bald eagle is the only one of our five study species for which the literature provides WTP estimates that can be used for a reasonably straightforward application of point value transfer.

Approach No. 2: Value transfer based on meta-analysis function for threatened, endangered or rare species

In addition to the point value transfer as used in Approach 1 above, WTP estimates for our target species may also be constructed using value function transfer approaches. Such approaches can be based on demand or meta-analysis functions. Meta-analysis, an approach extensively used in epidemiology, attempts to explain the variation in the results of existing, original studies by examining whether there exists a statistical relation between study results and study context, where context in natural resource applications includes demographic and natural resource characteristics as well as methodological approach.

Whether point value transfer or function-based value transfer are preferable in a given case depends on whether or not an original study is available whose context closely resembles that for which values are sought (the "policy site"). In our case, original WTP studies are available for two of our five target species. However, in the case of the bald eagle, these studies are from other geographic areas in the US (northern Midwest, New England and Northwest), employ two different response formats (dichotomous choice and open-ended) and measure WTP of visitors or area residents, in either lump-sum or annual payment form, for avoided species population losses or for population increases far larger than in our study. All of these variables have been identified in the literature as having a significant influence on WTP, raising the question of which of the five available WTP estimates constitutes the best source for a point value transfer. In the case of the red-cockaded woodpecker, the only available WTP study surveyed households located in the same geographic region (South Carolina or Mississippi, respectively) as our study, but one (Reaves et al. 1999) estimates WTP for *% chance of species survival*, a metric that is difficult to relate to our metric of *% avoided loss of species population*.

When no study with a closely matching valuation context is available, a function based value transfer may yield more reliable estimates because the values of the independent variables can be set to reflect the context of the policy site and thus can correct for differences among the study and policy sites (Rosenberger and Loomis, 2003). Several studies in the literature use meta-analysis-based WTP function transfers to generate WTP estimates for species conservation (Kroeger and Casey, 2006; Loomis, 2006).

In a recent update of an earlier study (Loomis and White, 1996), Richardson and Loomis (2009) estimate a function that predicts the WTP for the conservation of a threatened, endangered or rare species based on significant species and study characteristics identified through a meta-analysis of existing original studies. The authors recommend their reduced double-log Model Number 3 for benefit transfer applications because that model specification includes more species characteristics and fewer methodological variables than the best fit models. This model takes the following form:

$$\ln WTP\ (2006\ \$) = -153.231 + 0.870 \ln CHANGESIZE + 1.256\ VISITOR + 1.020\ FISH + 0.772\ MARINE + 0.826\ BIRD - 0.603 \ln RESPONSERATE + 2.767\ CONJOINT + 1.024\ CHARISMATIC - 0.903\ MAIL + 0.07754\ STUDYYEAR,$$

where *CHANGESIZE* is the percent change in population of the species in question, *VISITOR* is an indicator (binary) variable whose value is set to 1 if the respondent is a visitor to the area and to zero otherwise, *FISH*, *MARINE* (mammal) and *BIRD* are species type indicator variables, *RESPONSERATE* is the percent of individuals who responded to the survey, *CONJOINT* is an indicator variable that is set to 1 if the study uses conjoint methodology and to zero otherwise, *CHARISMATIC* is an indicator variable that is set to 1 if the species exhibits characteristics attractive to people, including what Metrick and Weitzman (1996) refer to as "visceral" characteristics such as being a higher life form or of large size as well physical appearance and public profile (Samples et al., 1986), *MAIL* is an indicator variable set to one if the survey was conducted by mail, and *STUDYYEAR* is the year in which the study is conducted.

This model, which has a within-sample benefit transfer error of 34 - 45% (Richardson and Loomis, 2009), can be used to estimate WTP for our five species by setting the *FISH*, *MARINE*, *BIRD* and *CHARISMATIC* variables to their appropriate values for the respective species, setting the *CHANGESIZE* variable to the percent avoided species population loss obtained from our expert interviews, setting *STUDYYEAR* to the current year (2011), and setting the remaining indicator variables to their average values from the WTP studies over which the equation above was estimated (Loomis and White 1996) (see Appendix 4).

Approach No. 3: Developing WTP estimates for Florida black bear and Florida scrub jay by scaling literature WTP estimates using protection expenditure ratios

Both original studies (e.g., Samples et al. 1986) and the statistical significance of the species indicator variables (*FISH*, *MARINE*, *BIRD*, and *CHARISMATIC*) in Richardson and Loomis' (2009) meta-analysis show that people's WTP for the conservation of a species is influenced by the attractiveness of the species to people, based on characteristics that include the species' size, physical appearance and public profile.

Likewise, a few studies that examined the relation between species characteristics and public conservation spending under the Endangered Species Act concludes that scientific characteristics such as degree of endangerment or taxonomic uniqueness do not have high explanatory power with respect to actual spending outlays. In fact, Metrick and Weitzman (1996) found that what they refer to as "visceral" characteristics such as being a higher life form and physical size were much better predictors of federal conservation spending on threatened or endangered species than scientific characteristics.

Dawson and Shogren (2001) also examined public conservation spending on threatened or endangered species and agree that species "charisma" may be an explanatory factor in allocation decisions about spending on endangered species. Even so, the authors argue that their analysis suggests that other variables such as a species' long-term cultural value, importance of the species' habitat, and historical commercial or recreational uses of the species may also be important drivers of spending allocation decisions.

Whether a species' visceral characteristics (charisma) or long-term cultural value and past (and possible future) direct uses are the more important drivers of public spending on species conservation is not relevant to our argument that spending reflects people's perception and attitudes and thus values for particular species. Rather, all of these characteristics likely play a role in why individuals value different species differently. Metrick and Weitzman's (1996) and Dawson and Shogren's (2001) findings thus support our hypothesis that differential spending on species may be a reasonably valid indicator of (and is driven at least in part by) people's underlying relative value for particular species.

Based on this hypothesis, we develop WTP estimates for the two of our five species for which no WTP estimates exist in the literature and that based on our expert opinion survey are expected to benefit from stewardship lands – the Florida black bear and the Florida scrub jay – by using expenditure ratios to scale WTP values from the literature for the bald eagle.

Expenditure data were taken from USFWS *Federal and State Endangered and Threatened Species Expenditures* reports (USFWS 1995, through USFWS 2011) and cover the years 1994 through 2009. Additional expenditures were identified through queries of the National Fish and Wildlife Foundation's (NFWF) *Grants Library* and the Florida Fish and Wildlife Conservation Commission's (FWC, 2011) dataset of grants. Searches were performed for each of the five species of interest: Florida black bear, bald eagle, Florida scrub jay, gopher tortoise, and red cockaded woodpecker. We included all expenses on a given species whether or not they occurred in Florida, because our argument is that total spending on a species is an indicator of the total value people place on that species. In cases where a project had the objective of protecting more than one of our species, we assigned identical shares of the spending to each of those species.[11] All expenditures were converted to 2010 $using the Consumer Price Index.

Expenditures on all of the five species (Table 5) began prior to 1994, the first year of expenditure estimates included in our analysis. Thus, our approach of comparing expenditures on the five species over the 16-year time period included in the analysis avoids the obvious bias that would result from using expenditure time series of different lengths.[12] While it would be preferable to capture all spending for each species over the longest common time period,

[11] The most prominent example of this was the Longleaf Pine Protection in Southwest Georgia carried out by the Georgia Department of Natural Resources. (http://www.nfwf.org/AM/Template.cfm?Section=Library_Search&Template=/customsource/ProjectSearch/cindex.cfm&nfwf_grant_id=2008-0044-003)

[12] The bald eagle was delisted in 2007 as recovered, but spending on the species continued through the end of the period analyzed in our study (2009).

such an undertaking is beyond the scope of the present study.[13]

Because there is no WTP estimate for the red-cockaded woodpecker that can form the basis for a benefit transfer to our Florida population (see discussion under approach No. 1), we chose the bald eagle as the anchor for our scaling exercise. The spending ratios are shown in Table 6.

Based on these ratios, the imputed WTP values for the red cockaded woodpecker, black bear, scrub jay and gopher tortoise (Table 7) are derived by dividing the estimated WTP for an avoided loss in the bald eagle population derived in Approach No. 1 by the respective spending ratios. The bald eagle WTP values for the size of the expected avoided losses of the other four species are calculated using the elasticity of WTP with respect to population changes of 0.953 (see Approach No. 1). Note that no WTP estimate can be derived for the gopher tortoise since the results of our expert elicitation process indicate that the impact of stewardship lands on the population of this species is likely to be negligible. Due to the fact that these estimates are based on our WTP estimates for avoided bald eagle losses and because the latter are likely to be very conservative, these estimates are by design also very conservative.

[13] The bald eagle, for example, first received protection in 1940 under the Bald Eagle Protection Act, the Migratory Bird Treaty Act in 1972, and the Endangered Species Preservation Act in 1967. Assembling estimates of any associated expenditures would be a tall order.

Approach No. 2: Scaling individual household WTP to the relevant benefitshed

The WTP estimates derived in the preceding sections reflect the monetary value an individual household places on the respective avoided species losses. Thus, in order to derive the total WTP of Florida residents for the non-use values generated by the stewardship program through the protection of these species, the per-household values need to be multiplied by the number of households in the state (Pate and Loomis 1997; Loomis 2000). The fact that the response rate in WTP studies of endangered species is less than 100 percent may indicate that there are individuals who do not value the protection of threatened or endangered species. On the other hand, non-response may be due to a number of reasons other than lack of appreciation of threatened or endangered species. Such reasons may include survey fatigue (from scientific and commercial surveys); lack of time or unwillingness to sacrifice time to answer questions from strangers, especially in times of incessant telemarketing; privacy concerns; or doubts as to the practical impact the survey is likely to have. Still, in the interest of generating conservative estimates, the WTP estimates for the bald eagle developed in Approach No. 1 should be corrected for non-response, using the average non-response rate in surveys of local households in the literature (49.2%, based on studies in Loomis and White 1996). There were an estimated 7,076,539 households in Florida in 2005-2009 (US Census Bureau 2010).

Table 5. Total spending in 1994-2009 on five study species by USFWS and State of Florida (2010 $)

	Bald eagle	R-C woodpecker	FL black bear	FL Scrub-jay	Gopher tortoise
Total spending, 1994-2009	$295,880,853	$319,080,490	$147,102,529	$28,779,302	$66,030,507
Status:					
Federal	Listed: 1978; Delisted: 2007 (recovered)	E	Candidate species	T	Listed: 1987 (T, Western pop.) Candidate: 2009 (Eastern pop.)
State			T		

Notes: For expenditure data, see Appendix 5. E=Endangered; T=Threatened

Table 6. Spending ratios of bald eagle to red-cockaded woodpecker, black bear, scrub jay and gopher tortoise

	R-C woodpecker	FL black bear	FL Scrub Jay	Gopher Tortoise
Bald eagle to:	0.9	2.0	10.3	4.5

Some studies have documented a reduction in a household's WTP for species protection with increasing distance of the household from the location of the species (Pate and Loomis 1997; Loomis 2000). Thus, when summing the WTP of households over large geographies, WTP estimates should be adjusted for this "distance decay" (e.g., Kroeger and Casey 2006). However, the five species studied here all are present throughout large areas of Florida and thus people in the state who value their presence are at most a few hundred miles from the nearest locations at which these species are found. For this reason, adjusting for WTP distance decay seems unwarranted for our analysis.

Results

By avoiding land conversion and restricting land management practices on enrolled lands, Florida's Forest Stewardship Program reduces the loss and degradation of habitats of the nearly 50 threatened, endangered or otherwise rare species found on those lands. As a result, the program is likely to lead to the avoidance of reductions in the populations of these species, compared to what would occur in the absence of the stewardship program. For this study, we chose five species found on stewardship lands that are threatened, endangered or have Special State Concern status and queried experts on these species as to the population losses they might experience if their habitat on stewardship lands were to be lost.

The results of our expert elicitation process indicate that stewardship lands likely provide only small benefits in the form of avoided population losses for the five species selected for this analysis, due to the fact that less than 1% of the statewide potential habitat of each of these species is found on stewardship lands. The avoided population losses were 2.6% for the bald eagle to 0-5% for the red-cockaded woodpecker, and 1-3% for the Florida scrub-jay. Avoided population losses due to stewardship lands were thought to be not directly measurable for the Florida black bear, and negligible for the Gopher tortoise.

Nevertheless, these avoided losses do carry economic values, primarily in the form of existence values (non-use values). Because of the lack of any valuation studies for these species in Florida, we used second-best approaches to construct estimates of the economic value of the avoided species losses. We used three approaches to estimate the existence values for the avoided losses in bald eagles, red-cockaded woodpeckers and Florida scrub-jays. The first of these ("Approach 1") uses an existing WTP estimate from the published literature for the only one of our five study species for which such values exist in a form that can be scaled to our study context, namely, the bald eagle, and scales that estimate to our study context on the basis of the expected size of the avoided bald eagle population loss.

Our second set of WTP estimates for our study species ("Approach 2") is developed by applying a function that yields estimates of WTP for a change in a species' population based on species characteristics, size of population change and other variables identified as significant in the literature. This function was derived through a peer-reviewed statistical analysis of more than 30 original species valuation studies in the US (Richardson and Loomis, 2009). The variables in that function were set at the appropriate values for our study context to generate WTP estimates for our study species. Finally, our third set of estimates ("Approach 3") uses the WTP estimates for the bald

Table 7. Estimated annual WTP per household for red-cockaded woodpecker, black bear, scrub jay and gopher tortoise

	R-C woodpecker		FL black bear		FL Scrub Jay		Gopher Tortoise	
Est. avoided loss of pop.	Low	High	Low	High	Low	High	Low	High
	0%	5%	n/d[b]		1%	2%	n/d[c]	
Est. WTP, 2010 $[a]								
Low	n/a	0.08	n/a	n/a	0.001	0.003	n/a	n/a
High	n/a	0.14	n/a	n/a	0.002	0.005	n/a	n/a

Notes: [a]Based on WTP for bald eagle for respective avoided losses, scaled using spending ratios in Table 6. Avoided losses are the low and high estimates from expert elicitation process.

n/d = not determined, for the following reasons: [b] not directly measurable; [c] meaningful numerical estimate cannot be developed. Based on expert assessment (Table 2). n/a = not available.

eagle derived in Approach 1 and scales these to the red-cockaded woodpecker and Florida scrub-jay using the ratios of conservation expenditures on the respective species.

Approaches 1 and 3 are based on the same data and assumptions. Approach 1 uses WTP estimates for avoided losses in bald eagle populations from existing studies and scaled those estimates to the much smaller avoided loss in bald eagles analyzed in our study. It does so making the assumption that the value increases with each successive avoided unit of population loss. This assumption is based on a key tenet of economic theory that has generally been confirmed in the species valuation literature. In Approach 3, the WTP estimates for avoided bald eagle losses then are scaled to the red-cockaded woodpecker and Florida scrub-jay, two species that our expert elicitation process revealed are likely to benefit from the stewardship Lands program and for which no literature WTP estimates exist, on the basis of the ratios of the total conservation expenditures on these species during the 1994-2009 period.

While all of our WTP estimates are based on the application of WTP values or mathematical functions (the WTP function used in Approach 2, and the elasticity used in Approaches 1 and 3) reported in the peer-reviewed species valuation literature, they are nevertheless characterized by a high level of uncertainty. The reason for this uncertainty is that the sizes of the avoided population losses we examine in this study (0-5%) differ substantially from those analyzed in the literature, which range from 30% to 600%. Thus, our estimates are based on extrapolations of functions outside of the range over which those functions were estimated. This is likely the main reason why our two WTP estimates (Approach 1&3 and Approach 2, respectively) yield mean values that differ by a factor of over five (Table 8).

Based on these first approaches (Approach 1&3), and using appropriate discount rates for projects that yield long-term environmental impacts (Weitzman 2001) to convert annual WTP into lump-sum WTP, we estimate that the average household in Florida has a lump-sum WTP of $1.60 to $2.64 for a 3% avoided loss in the statewide population of bald eagles; of $4.98 for a 5% avoided loss in the red-cockaded woodpecker; and of only 17 cents for a 1-2% avoided loss in scrub-jays (Table 8). These estimates would imply that the average household in Florida would be willing to pay up to $8 (Approach 1&3) or $36 (Approach 2) for avoiding these losses. Both of these values seem plausible.

Summing these values over the 51% of Florida households who very conservatively are assumed to be willing to pay for the protection of threatened or endangered species yields a total statewide WTP of between $5.9 million (Approach 1&3) and $128 million (Approach 2) for the avoided population losses stewardship lands are expected to achieve for the bald eagle, red-cockaded woodpecker

Table 8. Lump sum WTP for avoided population losses of five threatened, endangered or rare species as a result of habitat protection from Stewardship Program enrollment

	Bald Eagle		R-C woodpecker		FL black bear		FL Scrub-jay		Gopher tortoise	
	Low	High	Low	High	Low	High	Low	High	Low	High
Lump sum WTP per household (2010 $)										
Approach 1	1.60	2.64	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Approach 2	10.93	10.93	0	17.04	n/a	n/a	4.20	7.68	n/a	n/a
Approach 3	n/a	n/a	0	4.98	n/a	n/a	0.05	0.17	n/a	n/a
Lump sum WTP, statewide (2010 $)										
Approach 1	5.75M	9.48M	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Approach 2	39.28M	39.28M	0	61.26M	n/a	n/a	15.10M	27.60M	n/a	n/a
Approach 3	n/a	n/a	0	17.91M	n/a	n/a	0.18M	0.60M	n/a	n/a

Notes: Low estimates combine low estimates of avoided population loss population and low estimated WTP; High estimates combine high estimate of avoided population loss and high WTP (Table 7). Approach 1: Bald eagle literature WTP estimates scaled to expected avoided bald eagle population loss; Approach 2: WTP estimates based on meta-analysis WTP transfer function; Approach 3: Literature WTP estimates for bald eagle scaled to avoided bald eagle population loss from stewardship lands, then scaled to other species using expenditure ratios. M = million.

and Florida scrub-jay (Table 9). The lower of these two estimates is derived by combining the lowest avoided species loss estimates with the lower WTP estimates, while the higher value is derived by combining the highest expected avoided losses with the highest WTP estimates. The mean estimates of each approach are $17 million and $91 million, respectively.

We expect that approaches 1 and 3 underestimate actual WTP for the avoided population losses brought about by the Forest Stewardship Program, and that approach 2 may overestimate actual WTP. However, both are derived through the careful application of estimates and valuation functions from the literature, so it is not possible to definitively state that one or the other of the two estimates is more likely to be a better approximation of actual WTP. Thus, our overall mean estimate of the total statewide lump sum WTP for the avoided bald eagle, red-cockaded woodpecker and Florida scrub-jay population losses expected to be brought about by the stewardship program is $54 million.

Note that our WTP estimates, in addition to being a function of the uncertainties associated with benefit transfer, also depend on the consulted experts' assessment of how stewardship lands impact the populations of the species included in our analysis, which in turn depend, among other things, on experts' expectations about the rate and location of conversion of unprotected lands. If species benefit more from stewardship lands, the value will be higher than estimated here; if they benefit less, it will be lower.

Also, while some of the literature cautions against adding WTP estimates derived independently for individual species, our doing so is unlikely to be problematic. Indeed, most surveys ask respondents to state their WTP for a particular species (for an exception, see Loomis 2000). It is also true that unless they are explicitly advised to take into account the fact that there are further species that need protection (and thus may require payments), respondents may assign a large portion of the share of their income they are willing to devote to species protection to the one species that is the focus of that survey. If this is the case, then adding the results of individual WTP studies would lead to a serious overestimation of the total amount people are willing to spend on species conservation (Brown and Shogren 1998). However, while our WTP estimates are independently derived for each of the three species, the fact that we are adding WTPs for only three species makes it unlikely that our estimates of total WTP would overstate the WTP of Florida households for the avoided population losses for these three species. Still, adding many more WTP estimates derived separately for individual species would likely result in an overestimate of total statewide WTP for avoided species population losses. In any case, since our analysis includes only three of the nearly 50 species found on stewardship lands that are threatened, endangered or otherwise of special concern, our estimates are likely to understate the total statewide WTP for the benefits the stewardship program generates in terms of the protection of such species.

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Table 9. Total lump sum WTP of Florida households for conservation benefits to bald eagle, red-cockaded woodpecker and Florida scrub-jay from stewardship lands

	WTP, 2010 $		
	Lower bound	Upper bound	Mean estimate
Approach 1/3	$5.93 million	$27.99 million	$16.96 million
Approach 2	$54.38million	$128.14 million	$91.26 million

Notes: Low estimates combine low estimates of avoided population loss population and low estimated WTP; High estimates combine high estimate of avoided population loss and high WTP (Table 7). Estimates assume that 49.2 percent of Florida households have a zero WTP for population increases in threatened or endangered species or species of special concern. Approach 1/3: Using Approach 1 to estimate WTP for bald eagle population increases and Approach 3 for increases in red-cockaded woodpecker and Florida scrub-jay. Approach 2: Using Approach 2 to estimate WTP for population increases in bald eagle, red-cockaded woodpecker and Florida scrub-jay.

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Appendix 1.

Studies estimating WTP for conservation of threatened, endangered or rare species in the US

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
Appleman	2008	Migratory shorebird viewing	Day trip		$125.43		DC	Delaware Bay visitors	200	64	Appleman	2009	Migratory shorebird viewing	Day trip
		Migratory shorebird viewing	Day trip		$73.70		PC	Delaware Bay visitors	195				Migratory shorebird viewing	Day trip
		Migratory shorebird viewing	Over-night		$527.27		DC	Delaware Bay visitors	110		Trip Cost			
		Migratory shorebird viewing	Over-night		$213.53		PC	Delaware Bay visitors	101		Trip Cost			
Bell et al.	2000	Salmon	Gain	100%		$138.64	DC	Grays Harbor, WA Households	357	49.1	Tax High Income	2003	Willingness to pay for local coho salm-on enhancment in coastal communities	Marine Resource Economics
		Salmon	Gain	100%		$91.55	DC	Grays Harbor, WA Households	357		Tax Low Income			
		Salmon	Gain	100%		$141.27	DC	Willapa Bay, WA Households	386	61.7	Tax High Income			
		Salmon	Gain	100%		$90.64	DC	Willapa Bay, WA Households	386		Tax Low Income			
		Salmon	Survival			$57.99	DC	Coos Bay, OR Households	424	58.4	Tax High Income			
		Salmon	Survival			$47.70	DC	Coos Bay, OR Households	424		Tax Low Income			
		Salmon	Survival			$91.99	DC	Tillamock Bay, OR Households	347	53.2	Tax High Income			
		Salmon	Survival			$28.39	DC	Tillamock Bay, OR Households	347		Tax Low Income			
		Salmon	Survival			$134.00	DC	Yaquina Bay, OR Households	357	59.7	Tax High Income			

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
Bendle and Bell	1992	West Indian manatee	Survival			$21.24		FL Households	357		Donation	1995	An estimation of the total willingnss to pay by Floridians to protect the endangered West Indian manatee through donations	Report to the Save the Manatee Club and the Florida Department of Environmental Protection's Bureau of Protected Species Management
Berrens et al.	1995	Silvery minnow	Survival			$37.77	DC	NM Residents	726	64	Trust Fund	1996	Valuing the protection of minimum instream flows in New Mexico	Journal of Agricultural and Resource Economics
Bowker and Stoll	1983	Whooping crane	Survival			$43.69	DC	TX and US Households	316	36	Foundation	1988	Use of Dichotomous Choice Nonmarket Methods to Value the Whooping Crane Resource	American Journal of Agricultural Economics
	1983	Whooping crane	Survival			$68.55	DC	Visitors	254	67	Foundation	1988	Use of Dichotomous Choice Nonmarket Methods to Value the Whooping Crane Resource	American Journal of Agricultural Economics
Boyle and Bishop	1984	Striped shiner	Survival			$8.32	DC	WI Households	365	73	Foundation	1987	Valuing Wildlife in Benefit-Cost Analyses: A Case Study Involving Endangered Species	Water Resources Research
		Bald eagle	Survival			$21.21	DC	WI Households	365		Foundation			
Chambers and Whitehead	2001	Gray wolf	Survival		$22.64		DC	Ely and St. Cloud, MN Househ.	352	56.1	One-time Tax	2003	A contingent valuation estimate of the benefits of wolves in Minnesota	Environmental and Resource Economics
Cummings et al.	1994	Squawfish	Survival			$11.65	OE	NM	723	42	State Taxes	1994	Substitution effects in CVM values	American Journal of Agricultural Economics

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
Duffield	1990	Gray wolf	Reintro-duction		$93.92		DC	Yellowstone Visitors	158	30.6	Membership	1991	Existence and non-consumptive values for wildlife: application of wolf recovery in Yellowstone National Park	W-133/Western Regional Science Assosiation Joint Session Mesuring Non-Market and Non-Use Values
Duffield	1991	Gray wolf	Reintro-duction		$162.10		DC	Yellowstone Visitors	1212	86	Membership	1992	An economic analysis of wolf recovery in Yellowstone: park visitor attitudes and values	In: Varley, J., Brewster, W. (Eds.), Wolves for Yellowstone?
Duffield	1992	Gray wolf	Reintro-duction		$37.43		DC	ID,MT,WY Households	189	46.6	Membership	1993		
USDOI	1993	Gray wolf	Reintro-duction		$28.37		DC	ID,MT,WY Households	335	69.6	Membership	1994		
USDOI	1993	Gray wolf	Reintro-duction		$21.59		DC	ID,MT,WY Households	345	69.6		1994		
Duffield and Patterson	1991	Arctic grayling	Gain	33%	$26.47		PC	US Visitors	157	27.3	Trust Fund	1992	Field testing existence values: comparison of hypothetical and cash transaction values	In: Rettig, B. (Ed.), Benefits and costs in natural resource planning
		Arctic grayling	Gain	33%	$19.84		PC	US Visitors	157	77.1	Trust Fund			
Giraud et al.	1996	Mexican spotted owl	Survival			$68.84	DC	US Households	688	54.4	Trust Fund	1999	Internal and external scope in willingness-to-pay estimates for threatened and endangered wildlife	Journal of Environmental Management
Giraud et al.	2000	Stellar sea lion	Survival			$70.90	DC	AK and US Households	1653	63.6	Federal Tax	2002	Economic benefit of the protection program for the stellar sea lion	Marine Policy
Hageman	1984	Gray whale	Survival			$45.94	PC	CA Households	180	21	Federal Tax	1985	Valuing marine mammal populations: benefit valuations in a multi-species ecosystem	Administrative Report LJ-85-22
		Bottlenose dolphin	Survival			$36.41	PC	CA Households	174		Federal Tax			

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
		Northern elephant seal	Survival			$34.50	PC	CA Households	180	21	Federal Tax			
		Sea otter	Survival			$39.80	PC	CA Households	174		Federal Tax			
Hagen et al.	1990	Northern spotted owl	Survival			$130.19	DC	US Households	409	46	Taxes, Woods Prices	1992	Benefits of Preserving Old Growth Forests and the Spotted Owl	Contemporary Policy Issues
King et al.	1985	Bighorn sheep	Survival			$16.99	OE	AZ Households	550	59	Foundation	1988	Total and existence values of a herd of desert bighorn sheep	Benefits and Costs in Natural Resource Planning, Interim Report
Kotchen and Reiling	1997	Peregrine falcon	Gain	87.5	$32.27		DC	ME Residents	206	63.1	One-time Tax	2000	Environmental Attitudes, Motivations, and Contingent Valution of Nonuse Values: A Case Study Involving Endangered Species	Ecological Economics
	1997	Shortnose sturgeon	Survival		$33.45		DC	ME Residents	326	63.1	One-time Tax			
Layton et al.	1998	East WA/ Columbia Fresh Fish	Gain	50%		$210.84	CE	WA Households	801	68	Payment	2001	Valuing Multiple Programs to Improve Fish Populations	Washington State Department of Ecology
		East WA/ Columbia Migrt Fish	Gain	50%		$146.57	CE	WA Households			Payment			
		West WA/ Puget Fresh Fish	Gain	50%		$229.31	CE	WA Households			Payment			
		West WA/ Puget Migrt Fish	Gain	50%		$307.76	CE	WA Households			Payment			
		West WA/ Puget Salt Fish	Gain	50%		$311.31	CE	WA Households			Payment			

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
Lew et al.	2000	Steller sea lion				$126.38	CE	U.S. Households	1952	60%	Taxes and Goods	2009	Valuing Enhancements to Endangered Species Protection under Alternative Baseline Futures: The Case of the Steller Sea Lion	Marine Resource Economics
Initial pop. size →	26k	Steller sea lion	Stable			$102.90	CE	U.S. Households	717	59%	Taxes and Goods			
Eastern pop. size ↓	26k	Steller sea lion	Stable			$126.70	CE	U.S. Households	717	59%	Taxes and Goods			
E 60k	26k	Steller sea lion	Gain	100%		$130.09	CE	U.S. Households	717	59%	Taxes and Goods			
E 80k	26k	Steller sea lion	Gain	100%		$153.48	CE	U.S. Households	717	59%	Taxes and Goods			
E 60k	26k	Steller sea lion	Gain	170%		$176.93	CE	U.S. Households	717	59%	Taxes and Goods			
E 80k	26k	Steller sea lion	Gain	170%		$200.18	CE	U.S. Households	717	59%	Taxes and Goods			
E 60k	26k	Steller sea lion	Gain	250%		$154.65	CE	U.S. Households	717	59%	Taxes and Goods			
E 80k	26k	Steller sea lion	Gain	250%		$180.23	CE	U.S. Households	717	59%	Taxes and Goods			
E 80k	45k	Steller sea lion	Stable			$55.67	CE	U.S. Households	648	64%	Taxes and Goods			
E 60k	45k	Steller sea lion	Gain	11%		$41.92	CE	U.S. Households	648	64%	Taxes and Goods			
E 80k	45k	Steller sea lion	Gain	11%		$98.10	CE	U.S. Households	648	64%	Taxes and Goods			
E 60k	45k	Steller sea lion	Gain	55%		$144.02	CE	U.S. Households	648	64%	Taxes and Goods			
E 80k	45k	Steller sea lion	Gain	55%		$199.61	CE	U.S. Households	648	64%	Taxes and Goods			
E 60k	45k	Steller sea lion	Gain	200%		$181.65	CE	U.S. Households	648	64%	Taxes and Goods			
E 80k	45k	Steller sea lion	Gain	200%		$239.11	CE	U.S. Households	648	64%	Taxes and Goods			
E 60k	60k	Steller sea lion	Gain	16%		$40.91	CE	U.S. Households	587	48%	Taxes and Goods			
E 80k	60k	Steller sea lion	Gain	16%		$72.78	CE	U.S. Households	587	48%	Taxes and Goods			
E 60k	60k	Steller sea lion	Gain	50%		$98.11	CE	U.S. Households	587	48%	Taxes and Goods			

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
E 80k	60k	Steller sea lion	Gain	50%		$130.57	CE	U.S. Households	587	48%	Taxes and Goods			
Loomis	1994	Salmon and steelhead	Gain	600%		$79.53	DC	Clallam Co., WA Households	284	77%	Federal Tax	1996	Measuring the eco-nomic benefits of removign dams and restoring the Elwha river: results of a contingent valuation study	Water Resources Research
		Salmon and steelhead	Gain	600%		$98.41	DC	WA Households	467	68%	Federal Tax	1996		
		Salmon and steelhead	Gain	600%		$91.67	DC	US Households	423	55%	Federal Tax	1996		
Loomis and Ekstrand	1996	Mexican spotted owl	Survival			$51.52	MB	US Households	218	56%	Payment	1997	Economic Benefits of Critical Habitat for the Mexican Spotted Owl: A Scope Test Using a Multiple-Bound Contingent Valuation Survey	Journal of Agricultural and Resource Economics
		62 T/E species	Survival			$62.57	MB	US Households	205	57%	Payment			
Loomis and Larson	1991	Gray whale	Gain	50%		$23.65	OE	CA Households	890	54%	Protection Fund	1994	Total Economic Values of Increasing Gray Whale Populations: Results from a Contingent Valution Survey of Visitors and Households	Marine Resource Economics
		Gray whale	Gain	100%		$26.53	OE	CA Households	890	54%	Protection Fund	1994		
		Gray whale	Gain	50%		$36.56	OE	CA Visitors	1003	71%	Protection Fund	1994		
		Gray whale	Gain	100%		$43.46	OE	CA Visitors	1003	71%	Protection Fund	1994		
Olsen et al.	1989	Salmon and steelhead	Gain	100%		$42.97	OE	Pac. NW Households	695	72%	Electric Bill	1991	Existence and sport values for doubling the size of Columbia river basin calmon and steelhead runs	Rivers
		Salmon and steelhead	Gain	100%		$95.86	OE	Pac. NW HH Option		72%	Electric Bill	1991		

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
		Salmon and steelhead	Gain	100%		$121.40	OE	Pac. NW Anglers	482	72%	Electric Bill	1991		
Reaves et al.	1992	Red Cockaded Wood-pecker	% Chance	99%		$14.69	OE	SC and US Households	225	53%	Recovery Fund	1999	Does Question Format Matter? Valuing an Endangered Species	Environmental and Resource Economics
		Red Cockaded Wood-pecker	% Chance	99%		$20.46	DC	SC and US Households	223	52%				
		Red Cockaded Wood-pecker	% Chance	99%		$13.14	PC	SC and US Households	234	53%				
Rubin et al	1987	Northern spotted owl	% Chance	50%		$38.61	OE	WA Households	249	23%		1991	A Benefit-Cost Analysis of Northern Spotted Owl	Journal of Forestry
		Northern spotted owl	% Chance	75%		$39.99	OE	WA Households	249	23%				
		Northern spotted owl	% Chance	100%		$60.84	OE	WA Households	249	23%				
Samples and Hollyer	1986	Monk seal	Survival		$165.80		DC	HI Households	165	40%	Preservation Fund	1989	Contingent valuation of wildlife resources in the presence of substitutes and complements	In: Johnson, R., Johnson, G. (Eds.), Economic Valuation of Natural Resources: Issues, Theory and Application
		Humpback whale	Survival		$239.53		DC	HI Households	165	40%	Money and Time			
Solomon et al.	2001	Florida manatee	Survival			$10.25		Citrus Co., FL	297	36%	Donation	2004		Ecological Economics
Stanley	2001	Riverside fairy shrimp	Survival			$31.93	PC	Orange Co., CA Households	242	32%	Tax	2001	Local Perception of Public Goods: Recent Assessments of Willingness-to-pay for Endangered Species	Contemporary Economic Policy
		All T/E Species in county	Survival			$66.97	PC	Orange Co., CA Households	281	35%	Tax			

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
Stevens et al.	1989	Bald eagle	Survival			$31.85	OE	NE Households	339	37%	Trust Fund	1991	Measuring the Existence Value of Wildlife: What Do CVM Estimates Really Show?	Land Economics
		Bald eagle	Survival			$45.21	DC	NE Households	339	37%	Trust Fund			
		Wild Turkey	Survival			$11.38	DC	NE Households	339	37%	Trust Fund			
		Wild Turkey	Survival			$15.36	OE	NE Households	339	37%	Trust Fund			
		Atlantic salmon	Survival			$10.00	DC	MA Households	169	30%	Trust Fund			
		Atlantic salmon	Survival			$11.12	OE	MA Households	169	30%	Trust Fund			
Swanson	1989	Bald eagle	Gain	300%	$349.69		DC	WA Visitors	747	57%	Membership	1993	Economics of non-game management: bald eagles in the Skagit river bald eagle natural area, Washington	In: Ph.D. Dissertation, Department of Agricultural Economics, Ohio State University
		Bald eagle	Gain	300%	$244.94		OE	WA Visitors	747	57%	Membership			
Wallamo and Lew	2008	Smalltooth sawfish	Recov-ered			$49.99	CE	US Households	465	62%	Taxes and goods	2011	Valuing improve-ments to threatened and endangered marine species: An application of stated preference choice experiments	Journal of Environmental Management
		Smalltooth sawfish	Threatened			$31.80	CE	US Households	465	62%	Taxes and goods			
		Puget Sound Chinook Salmon	Recov-ered			$43.96	CE	US Households	465	62%	Taxes and goods			
		Hawaiian monk seal	Recov-ered			$63.78	CE	US Households	465	62%	Taxes and goods			
		Hawaiian monk seal	Threatened			$40.94	CE	US Households	465	62%	Taxes and goods			
		All 3 species	Recov-ered			$158.12	CE	US Households	465	62%	Taxes and goods			

Studies estimating WTP for conservation of threatened, endangered or rare species in the US *continued*

Author(s)	Survey	Species	Change	% Change	Lump Sum	Annual	CVM	Location	Sample Size	Response Rate	Instrument	Survey	Species	Change
Whitehead	1991	Sea turtle	Survival			$19.01	DC	NC Households	207	35	Preservation Fund	1992	Ex ante willingness-to-pay with supply and demand uncertainty: implications for valuing a sea turtle protection programme	Applied Economics
USFWS	1999	Grizzly Bear	Reintro-duction			$58.93		ID/MN Local Households				2000	Grizzly Bear Recovery in the Bitterroot Ecosystem, Ch. 4: Environmental Consequences	
		Grizzly Bear	Reintro-duction			$54.48		ID/MN Regional Households				2000		
		Grizzly Bear	Reintro-duction			$48.61		US Households				2000		

Appendix 2.

Threatened, endangered and special conservation concern species found on Florida Forest Stewardship Lands

Listing	Status	Species	*FSL* Acres	Specific Map					Source	County or region	additional information
				Pnt	Rng	Pot	Cons	Crit			
Federal and State Threatened and Endangered Species											
F	E	Bat, gray (Myotis grisescens)	17755			x			FGDL	Jackson	almost exclusive to caves
S	T	Big Cypress fox squirrel	826			x			FGDL	n/a	n/a
F	T	Caracara, Audubon's crested (Polyborus plancus audubonii)	14567			x	x		FGDL	n/a	n/a
S	T	Florida black bear	192921	x	x	x			FGDL	n/a	n/a
S	T	Florida sandhill crane	57382			x			FGDL	n/a	n/a
F	E	Kite, Everglade snail (Rostrhamus sociabilis plumbeus)	19957			x	x	x	FGDL	n/a	n/a
F	E	Panther, Florida (Puma (=Felis) concolor coryi)	1369			x	x	x	FGDL	n/a	n/a
F	T	Salamander, frosted flatwoods (Ambystoma cingulatum)	59252		p	x			FGDL	n/a	n/a
F	E	salamander, Reticulated flat-woods (Ambystoma bishopi)	59252		p	x			FGDL	n/a	n/a
F	T	scrub-jay, Florida (Aphelocoma coerulescens)	68306	x	x	x	x		FGDL	n/a	n/a
F	T	Skink, sand (Neoseps reynoldsi)	867	x	p	x			FGDL	n/a	n/a
S	T	Southeastern American kestrel	116486			x			FGDL	n/a	n/a
F	E	Woodpecker, red-cockaded (Picoides borealis)	74585	x		x	x		FGDL	n/a	n/a
State Special Concern											
S	SSC	burrowing owl	2050			x			FGDL	n/a	n/a
S	SSC	Scott's seaside sparrow	2393			x			FGDL	n/a	n/a

Threatened, endangered and special conservation concern species found on Florida Forest Stewardship Lands *continued*

Listing	Status	Species	*FSL* Acres	Specific Map					Source	County or region	additional information
				Pnt	Rng	Pot	Cons	Crit			
S	SSC	Sherman's fox squirrel	112225			x			FGDL	n/a	Need more data to better determine status of this species
Additional Species of Interest											
		American swallow-tailed kite	245493			x			FGDL	n/a	n/a
		Bald Eagle	256576		x	x			FGDL	n/a	n/a
		Striped newt	48637		x	x			FGDL	n/a	n/a
		Short-tailed hawk	17656			x			FGDL	n/a	n/a
		Cooper's hawk	89185			x			FGDL	n/a	n/a
		Mottled duck	35194			x			FGDL	n/a	n/a
		Florida mouse	41119			x			FGDL	n/a	n/a
		limpkin	47836			x			FGDL	n/a	n/a
		Louisiana seaside sparrow	66			x			FGDL	n/a	n/a
		Painted bunting	8655			x			FGDL	n/a	n/a
		Pine Barrens tree frog	9954		p	x			FGDL	n/a	n/a
		Seal salamander	545			x			FGDL	n/a	n/a
F	Candidate	Gopher tortoise	247372	x		x	x		FGDL	n/a	n/a
Species with County-Level Ranges ONLY											disjunct hibernation records
F	E	Bat, Indiana (Myotis sodalis)			x				USFWS	Jackson	Fakahatchee Strand - one possible FSL property

Threatened, endangered and special conservation concern species found on Florida Forest Stewardship Lands *continued*

Listing	Status	Species	*FSL* Acres	Specific Map					Source	County or region	additional information
				Pnt	Rng	Pot	Cons	Crit			
S	T	Everglades mink			x				FWC	Everglades, Big Cypress	n/a
S	T	Florida mastiff bat			x				FWC	Broward, Miami-Dade, Charlotte, Collier, Monroe	n/a
S	T	least tern			x				FNAI	Coastal Florida	n/a
S	T	short-tailed snake			x				FNAI	Northern and central peninsular Florida	n/a
F	T	Skink, bluetail mole (Eumeces egregius lividus)			x				USFWS	Highlands, Osceola, Polk Counties; Lake Whales Ridge	
F	E	Warbler, Kirtland's (Dendroica kirtlandii)			x				USFWS	Collier, Martin, Miami-Dade, Palm Beach, St. Lucie Counties	not overwintering

Threatened, endangered and special conservation concern species found on Florida Forest Stewardship Lands *continued*

Listing	Status	Species	*FSL* Acres	Specific Map					Source	County or region	additional information
				Pnt	Rng	Pot	Cons	Crit			
S	SSC	American oystercatcher			x				FNAI	Coastal Florida, excluding South and parts of panhandle	n/a
S	SSC	Barbour's map turtle			x				FNAI	Apalachicola, Chocta-watchee, Ochlockonee Rivers	n/a
S	SSC	Eastern chipmunk			x				FNAI	Western Panhandle	Need more data to better determine status of this species
S	SSC	Georgia blind salamander			x				FNAI	Jackson	Caves only
S	SSC	little blue heron			x				FNAI	Statewide	n/a
S	SSC	Marian's marsh wren			x				FNAI	Gulf Coast North of Pasco	n/a
S	SSC	reddish egret			x				FNAI	Coastal Florida	breeding densest near Keys
S	SSC	roseate spoonbill			x				FNAI	Peninsular Florida	breeding densest in Florida Bay
S	SSC	Sherman's short-tailed shrew			x				FNAI	Lee	subspecies possibly extinct
S	SSC	tricolored heron			x				FNAI	Statewide	concentrated on coasts of peninsular Florida

Threatened, endangered and special conservation concern species found on Florida Forest Stewardship Lands *continued*

Listing	Status	Species	*FSL* Acres	Specific Map					Source	County or region	additional information
				Pnt	Rng	Pot	Cons	Crit			
S	SSC	Wakulla seaside sparrow			x				FNAI	Taylor, Jefferson, Wakulla, Franklin	coastal marshes
S	SSC	Worthington's marsh wren			x				FNAI	Nassau, Duval	salt marshes

Notes: Listing status: F = federal, FGDL = Florida Geographic Data Library, FNAI = Florida Natural Areas Inventory, FSL = Florida Stewardship Lands, FWC =Florida Fish and Wildlife Conservation Commission, S = state, T = threatened, E = endangered, SSC = state special concern, USFWS = U.S. Fish and Wildlife Service. Map descriptors: Pnt = point, Rng = range, Cons = conservation plan, Pot = potential, Crit = critical habitat, p = potential, n/a = no additional data.

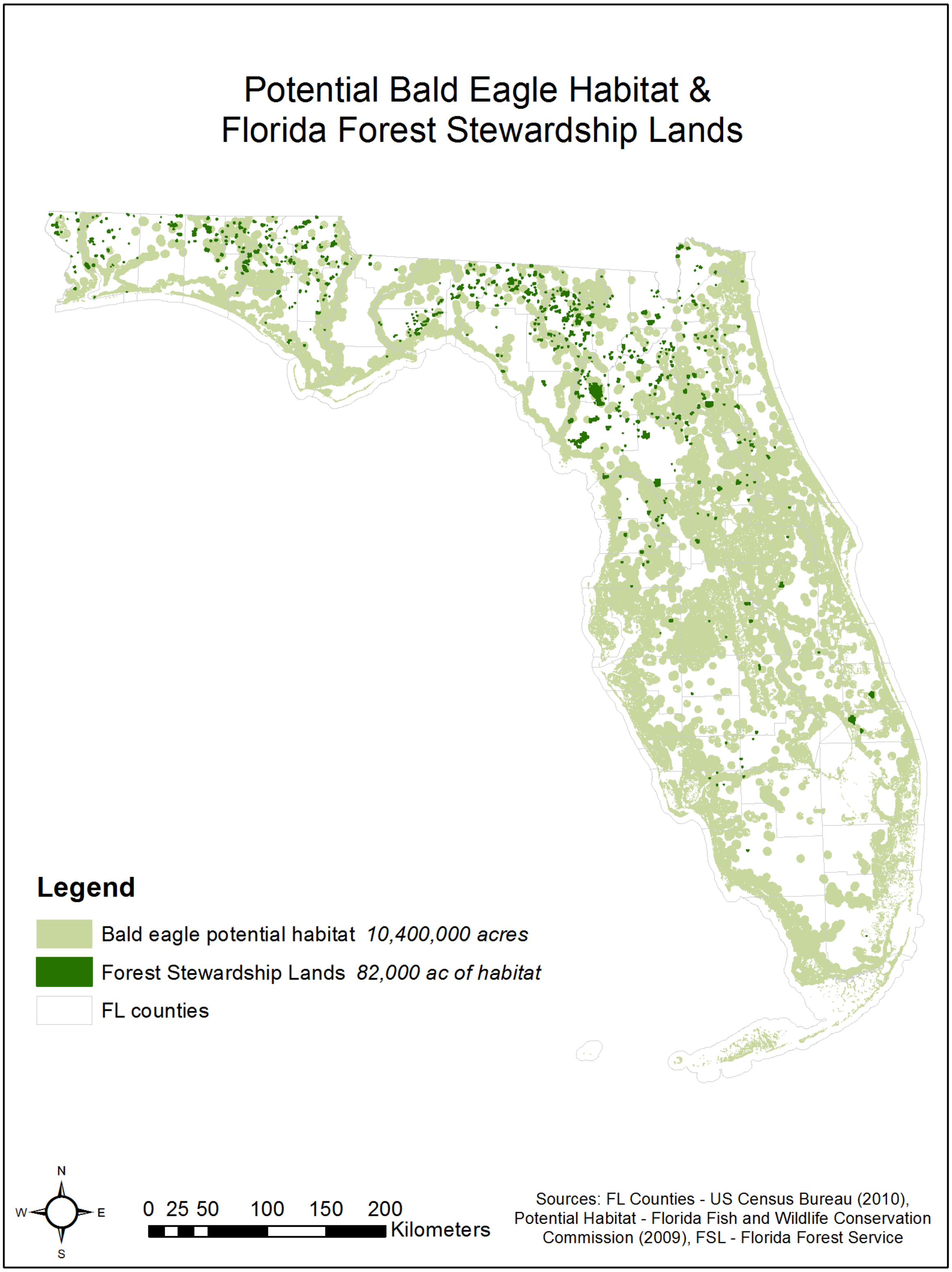
USFWS and FFWCC spending on Florida gopher tortoise conservation

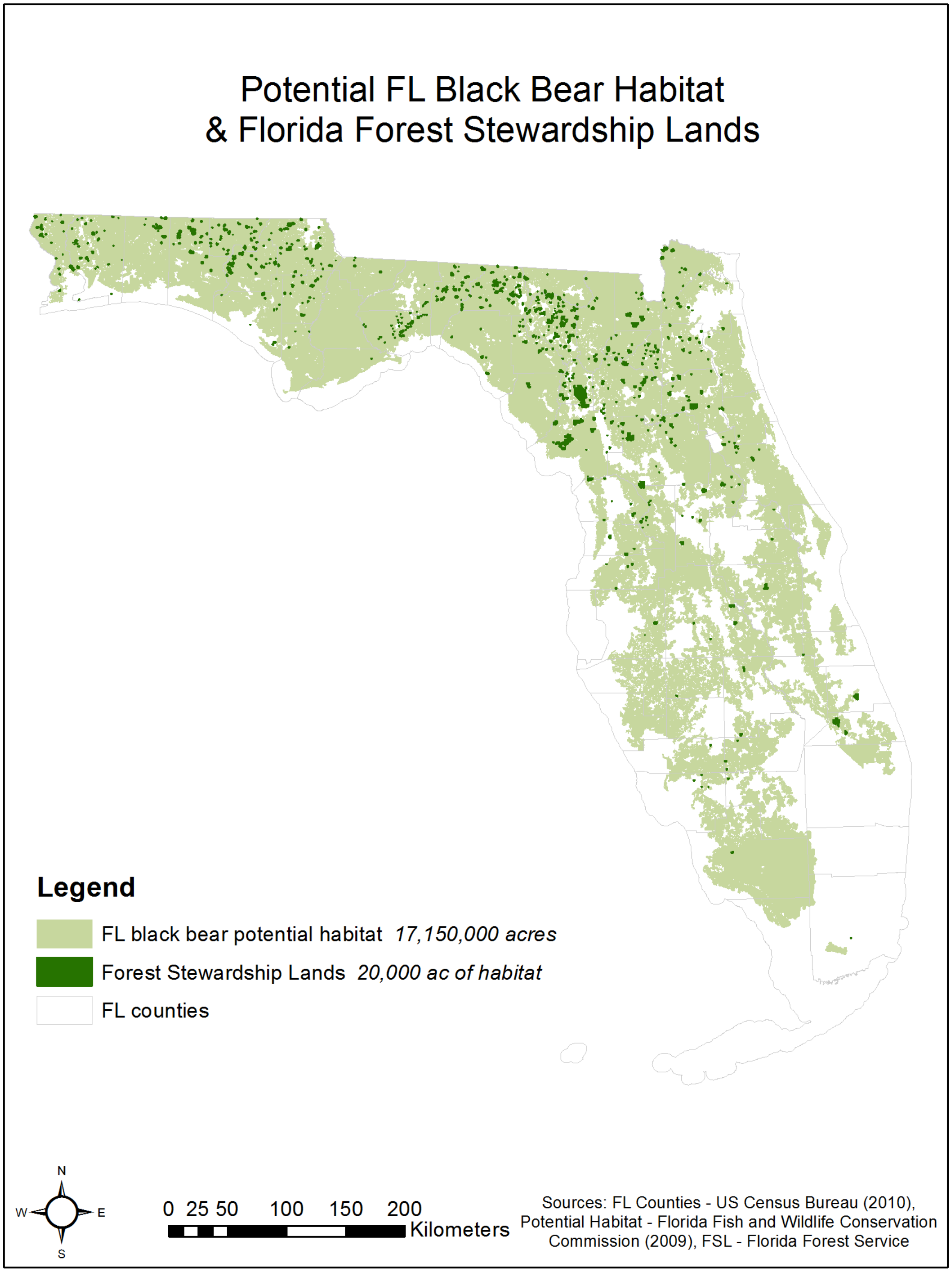
	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Non-Land	1994	$69,000	$98,500	$167,500	$100	$167,600	$246,372	n/a
Non-Land	1995	$21,700	$135,560	$157,260	$-	$157,260	$224,882	n/a
Non-Land	1996	$74,000	$154,980	$228,980	$5,000	$233,980	$325,232	n/a
Non-Land	1997	$30,000	$840,000	$870,000	$8,000	$878,000	$1,194,080	n/a
Non-Land	1998	$158,500	$264,000	$422,500	$-	$422,500	$566,150	n/a
Non-Land	1999	$102,500	$235,010	$337,510	$4,500	$342,010	$448,033	n/a
Non-Land	2000	$135,000	$310,510	$445,510	$56,500	$502,010	$637,553	n/a
Non-Land	2001	$153,000	$282,800	$435,800	$82,500	$518,300	$637,509	n/a
Non-Land	2002	$178,000	$622,200	$800,200	$85,000	$885,200	$1,071,092	n/a
Non-Land	2003	$293,000	$2,009,195	$2,302,195	$82,500	$2,384,695	$2,837,787	Population west of Mobile/Tombigbee Rivers
Non-Land	2004	$109,500	$1,944,600	$2,054,100	$48,000	$2,102,100	$2,417,415	Population west of Mobile/Tombigbee Rivers
Non-Land	2005	$157,500	$1,974,600	$2,132,100	$-	$2,132,100	$2,387,952	Population west of Mobile/Tombigbee Rivers
Non-Land	2006	$56,500	$13,291,959	$13,348,459	$-	$13,348,459	$14,416,336	Population west of Mobile/Tombigbee Rivers
Non-Land	2007	$43,000	$3,019,826	$3,062,826	$15,220	$3,078,046	$3,231,948	Population west of Mobile/Tombigbee Rivers
Non-Land	2008	$48,000	$386,751	$434,751	$9,650	$444,401	$448,845	Population west of Mobile/Tombigbee Rivers
Non-Land	2009	$153,500	$845,978	$999,478	$1,492	$1,000,970	$1,020,989	Population west of Mobile/Tombigbee Rivers
Land Acq.	1994	$-	$-	$-	$-	$-		n/a
Land Acq.	1995	$-	$-	$-	$-	$-		n/a

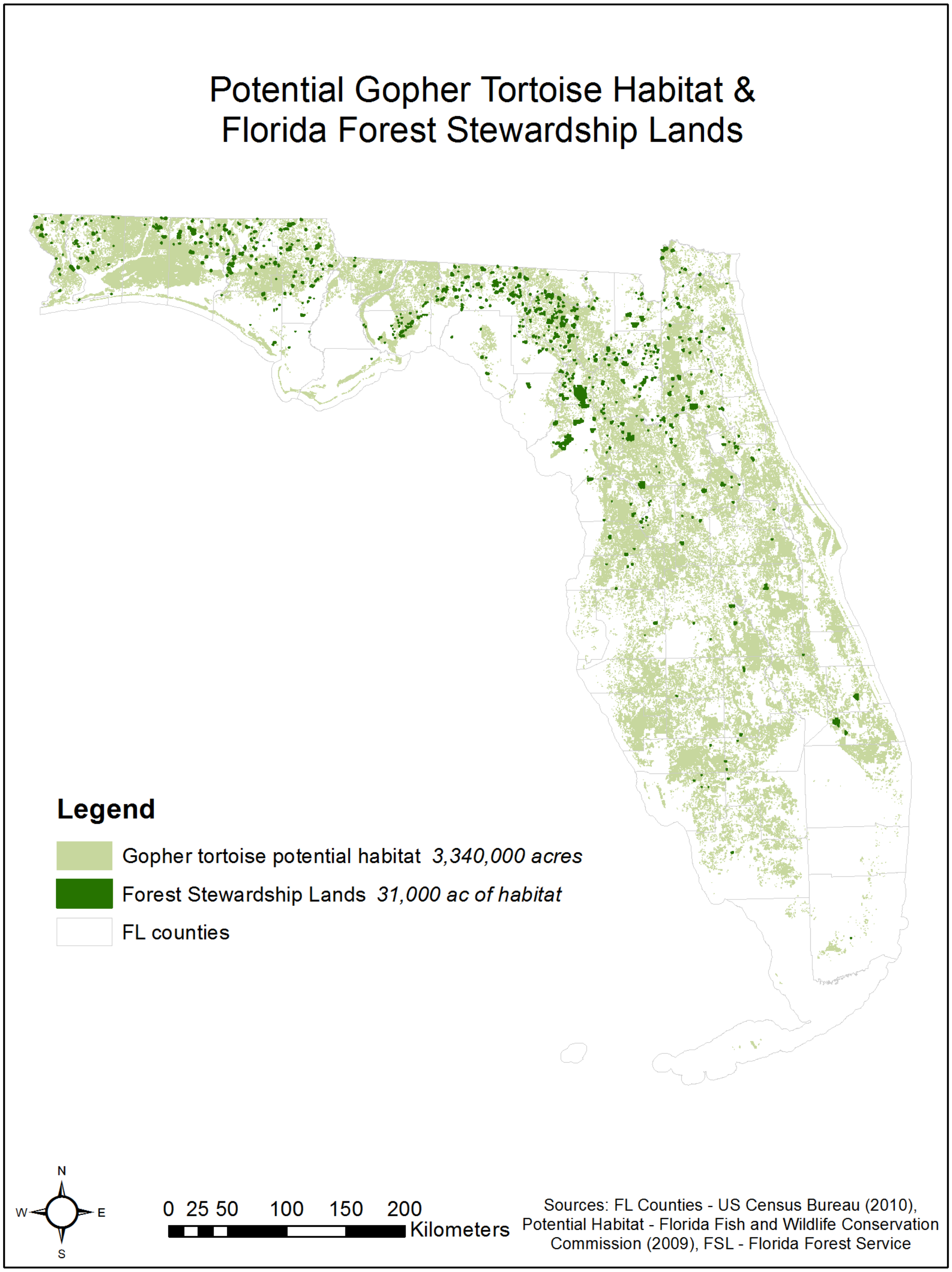
USFWS and FFWCC spending on Florida gopher tortoise conservation *continued*

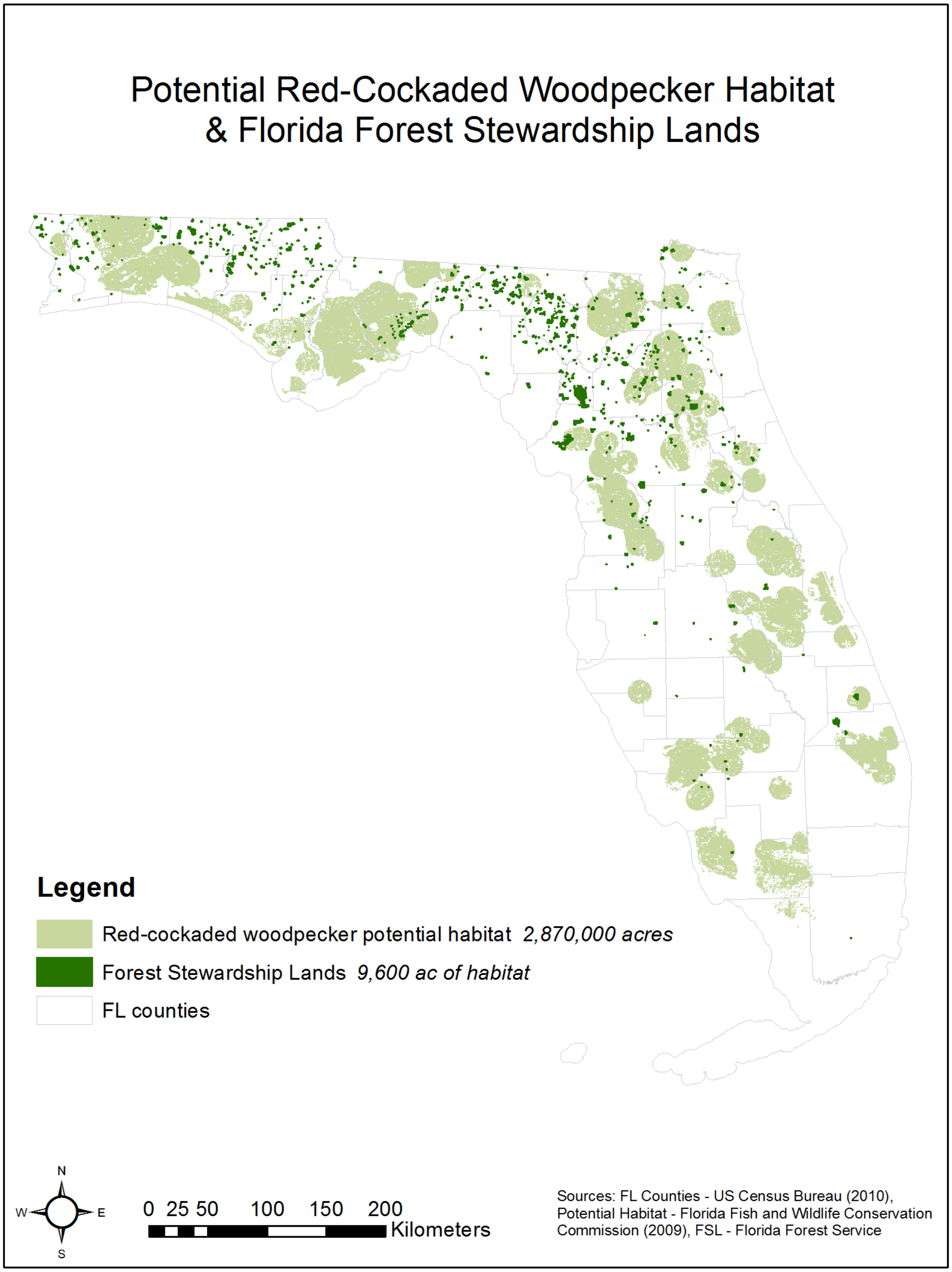
	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Land Acq.	1996	$-	$-	$-	$-	$-		n/a
Land Acq.	1997	$-	$-	$-	$-	$-		n/a
Land Acq.	1998	$-	$-	$-	$-	$-		n/a
Land Acq.	1999	$485,000	$-	$485,000	$-	$485,000	$635,350	n/a
Land Acq.	2000	$1,562,000	$-	$1,562,000	$-	$1,562,000	$1,983,740	n/a
Land Acq.	2001	$832,000	$486,500	$1,318,500	$-	$1,318,500	$1,621,755	n/a
Land Acq.	2002	$51,000	$-	$51,000	$1,400,000	$1,451,000	$1,755,710	n/a
Land Acq.	2003	$-	$480,000	$480,000	$-	$480,000	$571,200	Population west of Mobile/Tombigbee Rivers
Land Acq.	2004	$-	$-	$-	$-	$-	$-	Population west of Mobile/Tombigbee Rivers
Land Acq.	2005	$13,125	$-	$13,125	$-	$13,125	$14,700	Population west of Mobile/Tombigbee Rivers
Land Acq.	2006	$-	$-	$-	$-	$-	$-	Population west of Mobile/Tombigbee Rivers
Land Acq.	2007	$-	$181,000	$181,000	$-	$181,000	$190,050	Population west of Mobile/Tombigbee Rivers
Land Acq.	2008	$-	$-	$-	$-	$-	$-	Population west of Mobile/Tombigbee Rivers
Land Acq.	2009	$-	$731,000	$731,000	$-	$731,000	$745,620	Population west of Mobile/Tombigbee Rivers

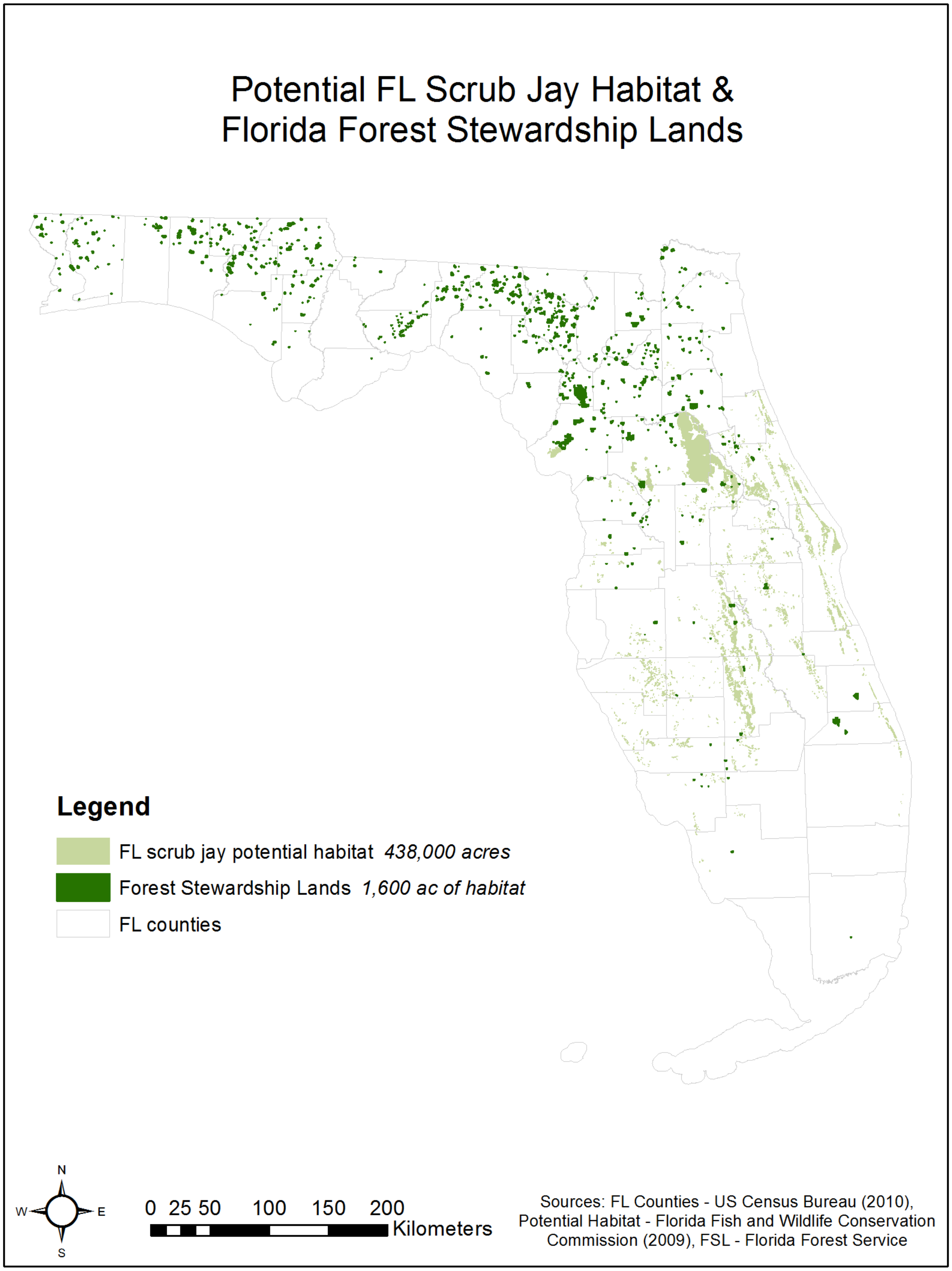
USFWS = U.S. Fish and Wildlife Service. FFWCC = Florida Fish and Wildlife Conservation Commission. Map descriptors: Pnt = point, Rng = range, Cons = conservation plan, Pot = potential, Crit = critical habitat, p = potential, n/a = no additional data, $- = No spending data.


Potential Bald Eagle Habitat &
Florida Forest Stewardship Lands
Legend
Bald eagle potential habitat 10,400,000 acres
Forest Stewardship Lands 82,000 ac of habitat
FL counties
N
W
E
S
0 25 50 100 150 200
Kilometers
Sources: FL Counties - US Census Bureau (2010),
Potential Habitat - Florida Fish and Wildlife Conservation
Commission (2009), FSL - Florida Forest Service


Potential FL Black Bear Habitat
& Florida Forest Stewardship Lands
Legend
FL black bear potential habitat 17,150,000 acres
Forest Stewardship Lands 20,000 ac of habitat
FL counties
N
W
E
S
0 25 50 100 150 200
Kilometers
Sources: FL Counties - US Census Bureau (2010),
Potential Habitat - Florida Fish and Wildlife Conservation
Commission (2009), FSL - Florida Forest Service


Potential Gopher Tortoise Habitat &
Florida Forest Stewardship Lands
Legend
Gopher tortoise potential habitat 3,340,000 acres
Forest Stewardship Lands 31,000 ac of habitat
FL counties
N
W
E
S
0 25 50 100 150 200
Kilometers
Sources: FL Counties - US Census Bureau (2010),
Potential Habitat - Florida Fish and Wildlife Conservation
Commission (2009), FSL - Florida Forest Service


Potential Red-Cockaded Woodpecker Habitat
& Florida Forest Stewardship Lands
Legend
Red-cockaded woodpecker potential habitat 2,870,000 acres
Forest Stewardship Lands 9,600 ac of habitat
FL counties
N
W
E
S
0 25 50 100 150 200
Kilometers
Sources: FL Counties - US Census Bureau (2010),
Potential Habitat - Florida Fish and Wildlife Conservation
Commission (2009), FSL - Florida Forest Service


Potential FL Scrub Jay Habitat &
Florida Forest Stewardship Lands
Legend
FL scrub jay potential habitat 438,000 acres
Forest Stewardship Lands 1,600 ac of habitat
FL counties
N
W
E
S
0 25 50 100 150 200
Kilometers
Sources: FL Counties - US Census Bureau (2010),
Potential Habitat - Florida Fish and Wildlife Conservation
Commission (2009), FSL - Florida Forest Service

Appendix 3.

Example of text used in expert questionnaire (Red-cockaded woodpecker)

IFAS Stewardship Ecosystem Services Study: Expert interviews on T&E species population impacts of stewardship lands

Dear survey participant,

This expert interview forms part of a larger study that examines the ecosystem services provided by lands enrolled in the State of Florida's Forest Stewardship Program. The study is conducted by the School of Forest Resources and Conservation of the University of Florida's Institute of Food and Agricultural Sciences (IFAS).

As part of that study, we are attempting to develop estimates of the impact that Stewardship lands have on the conservation of selected threatened, endangered or rare species. More specifically, we are interested in understanding by what percentage the Florida populations of the following species might be reduced if their habitats on Stewardship lands were to disappear:

- Florida black bear (*Ursus americanus floridanus*);
- Florida scrub Jay (*Aphelocoma coerulescens*);
- Red cockaded woodpecker (*Picoides borealis*);
- Bald eagle (*Haliaeetus leucocephalus*); and
- Gopher tortoise (*Gopherus polyphemus*).

To answer this question, we are interviewing experts for each species such as yourself to obtain their best professional estimate of the population reductions they would expect to result from the complete loss of a species habitat on Stewardship lands.

Below, we are providing maps of the total habitat of Red cockaded woodpecker (*Picoides borealis*) in Florida and Forest Stewardship lands. Based on information from the US Fish and Wildlife Service and the Florida Wildlife Commission, Stewardship lands account for approximately 0.3 percent of the total statewide habitat acreage of the species.

In your answer, please consider all relevant aspects including connectivity, patch size and habitat structure. Also keep in mind how future land development in Florida may impact habitat on non- Forest Stewardship Lands relative to those lands enrolled in the Forest Stewardship Program.

Please indicate the rough level of confidence you have in your estimate (high, medium, low), and the associated reasons for your level of confidence.

Appendix 4.

Values at which variables in the meta-analysis function were set for WTP estimation.

	Bald eagle	R-C woodpecker	FL Black bear	FL Scrub-jay	Gopher tortoise
Changesize	2.6%	0 - 5%	n/a	1 – 2%	n/a
Visitor	Set to "0" for all species				
Fish	Set to "0" for all species				
Marine	Set to "0" for all species				
Bird	1	1	0	1	0
Responserate	Set to "49.1" for all species (average of studies used to estimate WTP function)				
Conjoint	Set to "0" for all species				
Charismatic	Set to "1" for all species				
Mail	Set to "85.1%" for all species (average of studies used to estimate WTP function)				
Studyyear	Set to "2011" for all species, to generate WTP estimates for the year of this study				

Note: values of the CHANGESIZE variable are based on results of expert elicitation process.

Appendix 5. Expenditures for species conservation

Table 1. FWS and Florida FFWCC spending on bald eagle conservation

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Non-Land	1994	$1,261,400	$3,545,200	$4,806,600	$751,100	$5,557,700	$8,169,819	n/a
Non-Land	1995	$1,541,770	$3,902,180	$5,443,950	$989,160	$6,433,110	$9,199,347	n/a
Non-Land	1996	$229,800	$3,363,080	$3,662,880	$947,900	$4,610,770	$6,408,970	n/a
Non-Land	1997	$1,077,120	$3,359,480	$4,436,600	$801,370	$5,237,960	$7,123,626	n/a
Non-Land	1998	$1,448,900	$3,722,000	$5,170,900	$828,500	$5,999,430	$8,039,236	n/a
Non-Land	1999	$1,720,000	$4,014,500	$5,734,500	$835,620	$6,570,120	$8,606,857	n/a
Non-Land	2000	$1,286,500	$4,168,670	$5,455,170	$1,049,690	$6,504,860	$8,261,172	n/a
Non-Land	2001	$1,331,410	$5,800,713	$7,132,123	$1,151,600	$8,283,723	$10,188,979	n/a
Non-Land	2002	$1,427,975	$4,232,261	$5,660,236	$1,011,500	$6,671,736	$8,072,801	n/a
Non-Land	2003	$1,990,471	$4,932,950	$6,923,421	$908,110	$7,831,531	$9,319,522	n/a
Non-Land	2004	$3,055,703	$5,670,187	$8,725,890	$1,111,350	$9,837,240	$11,312,826	n/a
Non-Land	2005	$3,771,556	$8,605,926	$12,377,482	$1,084,846	$13,462,328	$15,077,807	n/a
Non-Land	2006	$3,510,356	$8,008,445	$11,518,801	$806,085	$12,324,886	$13,310,877	n/a
Non-Land	2007	$1,268,404	$7,210,744	$8,479,148	$977,170	$9,456,318	$9,929,134	n/a
Non-Land	2008	$100,000	$698,187	$798,187	$311,195	$1,109,382	$1,120,476	n/a
Non-Land	2009	$99,478	$502,267	$601,745	$464,399	$1,066,144	$1,087,467	n/a
								n/a
Land Acq.	1994	$647,100	$31,500	$678,600	$-	$678,600	$997,542	n/a
Land Acq.	1995	$372,200	$-	$372,200	$-	$372,200	$532,246	n/a
Land Acq.	1996	$278,000	$-	$278,000	$232,500	$510,500	$709,595	n/a
Land Acq.	1997	$4,072,500	$827,000	$4,899,500	$299,300	$5,198,800	$7,070,368	n/a
Land Acq.	1998	$4,252,900	$1,304,600	$5,557,500	$-	$5,557,500	$7,447,050	n/a
Land Acq.	1999	$11,683,200	$19,800	$11,703,000	$1,583,000	$13,286,000	$17,404,660	n/a
Land Acq.	2000	$15,836,000	$1,016,550	$16,852,550	$449,400	$17,301,950	$21,973,477	n/a
Land Acq.	2001	$20,073,093	$1,350,260	$21,423,353	$320,800	$21,744,153	$26,745,308	n/a
Land Acq.	2002	$14,033,895	$241,601	$14,275,496	$1,018,800	$15,294,296	$18,506,098	n/a

Table 1. FWS and Florida FFWCC spending on bald eagle conservation *continued*

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Land Acq.	2003	$2,927,706	$3,362,000	$6,289,706	$1,911,900	$8,201,606	$9,759,911	n/a
Land Acq.	2004	$1,679,451	$6,083,800	$7,763,251	$44,300	$7,807,551	$8,978,684	n/a
Land Acq.	2005	$958,264	$6,021,500	$6,979,764	$-	$6,979,764	$7,817,336	n/a
Land Acq.	2006	$15,316,257	$4,517,620	$19,833,877	$-	$19,833,877	$21,420,587	n/a
Land Acq.	2007	$-	$1,153,912	$1,153,912	$2,112,000	$3,265,912	$3,429,208	n/a
Land Acq.	2008	$-	$3,642,499	$3,642,499	$-	$3,642,499	$3,678,924	n/a
Land Acq.	2009	$-	$3,167,000	$3,167,000	$-	$3,167,000	$3,230,340	n/a
Project	2004		$30,000	$60,000	Lake Wales Ridge Prescribed Fire Strike Team	FFWCC	$69,000	2005-2007
Project	2005		$49,210	$98,420	Lake Wales Ridge Prescribed Fire Strike Team	FFWCC	$110,230	2007-2008
Project	2007		$42,303	$84,605	Lake Wales Ridge Prescribed Fire Strike Team	FFWCC	$88,835	2008-2009
Management	One-time			$42,500	Bald Eagle Management Plan	FFWCC	$42,925	2008-2013
Management	Annual			$315,080	Bald Eagle Management Plan	FFWCC	$639,612	2008-2013
						TOTAL	$295,880,853	

Sources: U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission and National Fish and Wildlife Foundation. n/a = no additional data

Table 2. FWS and Florida FFWCC spending on red-cockaded woodpecker conservation

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Non-Land	1994	$827,000	$8,142,700	$8,969,700	$313,960	$9,109,300	$13,390,671	n/a
Non-Land	1995	$709,500	$7,437,690	$8,147,190	$137,870	$8,285,060	$11,847,636	n/a
Non-Land	1996	$617,700	$12,188,680	$12,806,380	$169,120	$12,975,500	$18,035,945	n/a
Non-Land	1997	$1,313,500	$10,651,230	$11,964,730	$91,180	$12,055,910	$16,396,038	n/a
Non-Land	1998	$1,079,500	$10,121,100	$11,200,600	$6,240	$11,262,990	$15,092,407	n/a
Non-Land	1999	$1,109,000	$9,560,840	$10,669,840	$42,630	$10,712,470	$14,033,336	n/a
Non-Land	2000	$1,502,500	$10,178,890	$11,681,390	$119,100	$11,800,490	$14,986,622	n/a
Non-Land	2001	$666,700	$8,179,677	$8,846,377	$171,600	$9,017,977	$11,092,112	n/a
Non-Land	2002	$1,977,800	$5,673,171	$7,650,971	$183,800	$7,834,771	$9,480,073	n/a
Non-Land	2003	$1,303,567	$9,564,002	$10,867,569	$201,500	$11,069,069	$13,172,192	n/a
Non-Land	2004	$2,096,000	$11,680,785	$13,776,785	$348,300	$14,125,085	$16,243,848	n/a
Non-Land	2005	$2,543,828	$9,942,757	$12,486,585	$242,806	$12,729,391	$14,256,918	n/a
Non-Land	2006	$2,039,592	$11,864,943	$13,904,535	$396,363	$14,300,898	$15,444,970	n/a
Non-Land	2007	$3,264,341	$13,834,395	$17,098,736	$816,655	$17,915,391	$18,811,161	n/a
Non-Land	2008	$1,506,200	$17,557,520	$19,063,720	$501,358	$19,565,078	$19,760,729	n/a
Non-Land	2009	$3,446,200	$20,987,461	$24,433,661	$1,002,156	$25,435,817	$25,944,533	n/a
								n/a
Land Acq.	1994	$-	$-	$-	$-	$-		n/a
Land Acq.	1995	$-	$-	$-	$-	$-		n/a
Land Acq.	1996	$-	$-	$-	$-	$-		n/a
Land Acq.	1997	$-	$-	$-	$-	$-		n/a
Land Acq.	1998	$942,200	$-	$942,200	$-	$942,200	$1,262,548	n/a
Land Acq.	1999	$485,000	$-	$485,000	$-	$485,000	$635,350	n/a
Land Acq.	2000	$1,583,000	$16,500	$1,599,500	$221,500	$1,821,000	$2,312,670	n/a
Land Acq.	2001	$820,000	$983,000	$1,803,000	$-	$1,803,000	$2,217,690	n/a
Land Acq.	2002	$51,000	$5,950,000	$6,001,000	$80,000	$6,081,000	$7,358,010	n/a
Land Acq.	2003	$241,000	$-	$241,000	$1,080,000	$1,321,000	$1,571,990	n/a
Land Acq.	2004	$1,901,000	$-	$1,901,000	$31,500	$1,932,500	$2,222,375	n/a
Land Acq.	2005	$4,104,000	$1,500,000	$5,604,000	$-	$5,604,000	$6,276,480	n/a

Table 2. FWS and Florida FFWCC spending on red-cockaded woodpecker conservation *continued*

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Land Acq.	2006	$64,168	$920,000	$984,168	$567,817	$1,551,985	$1,676,144	n/a
Land Acq.	2007	$319,000	$31,000	$350,000	$200,000	$550,000	$577,500	n/a
Land Acq.	2008	$121,500	$120,000	$241,500	$17,326,900	$17,568,400	$17,744,084	n/a
Land Acq.	2009	$30,889	$1,500,000	$1,530,889	$8,799,205	$10,330,094	$10,536,696	n/a
Project	2005				$27,401	$57,356	$64,239	Pebble Hill/Tall Timbers Longleaf Reforestation Tall Timbers Research, Inc.
Project	2006				$36,026	$76,795	$82,939	Dixon Memorial (GA) Longleaf Pine Restoration Georgia Forestry Commission
Project	2008				$1,000,000	$32,000,000	$16,160,000	Longleaf Pine Protection in Southwest Georgia Georgia Department of Natural Resources
Project	2008				$194,350	$388,700	$392,587	Gopher Tortoise Habitat Credit Bank (GA, AL) American Forest Foundation
							$319,080,490	n/a

Sources: U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission and National Fish and Wildlife Foundation. n/a = no additional data

Table 3. FWS and Florida FFWCC spending on Florida scrub-jay conservation

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	In 2010 $	Notes	Source
Non-Land	1994	$415,500	$304,500	$720,000	$3,500	$723,500	$1,063,545	n/a	n/a
Non-Land	1995	$86,000	$412,600	$4,986,000	$45,750	$544,350	$778,421	n/a	n/a
Non-Land	1996	$268,800	$447,000	$715,800	$45,750	$761,550	$1,058,555	n/a	n/a
Non-Land	1997	$275,000	$565,200	$840,200	$16,770	$856,970	$1,165,479	n/a	n/a
Non-Land	1998	$168,100	$340,800	$508,900	$3,200	$512,090	$686,201	n/a	n/a
Non-Land	1999	$330,000	$289,050	$619,050	$-	$619,050	$810,956	n/a	n/a
Non-Land	2000	$276,000	$761,030	$1,037,030	$14,000	$1,051,030	$1,334,808	n/a	n/a
Non-Land	2001	$493,000	$817,100	$1,310,100	$14,000	$1,324,100	$1,628,643	n/a	n/a
Non-Land	2002	$464,000	$998,917	$1,462,917	$14,000	$1,476,917	$1,787,070	n/a	n/a
Non-Land	2003	$253,500	$682,240	$935,740	$14,000	$949,740	$1,130,191	n/a	n/a
Non-Land	2004	$595,800	$737,111	$1,332,911	$30,300	$1,363,211	$1,567,693	n/a	n/a
Non-Land	2005	$716,500	$652,856	$1,369,356	$-	$1,369,356	$1,533,679	n/a	n/a
Non-Land	2006	$919,000	$1,592,709	$2,511,709	$75,353	$2,587,062	$2,794,027	n/a	n/a
Non-Land	2007	$555,500	$1,458,760	$2,014,260	$161,383	$2,175,643	$2,284,425	n/a	n/a
Non-Land	2008	$575,100	$1,032,662	$1,607,762	$51,491	$1,659,253	$1,675,846	n/a	n/a
Non-Land	2009	$697,000	$2,508,884	$3,205,884	$37,833	$3,243,717	$3,308,591	n/a	n/a
Land Acq.	1994	$-	$-	$-	$-	$-		n/a	n/a
Land Acq.	1995	$4,040	$-	$4,040	$-	$4,040	$5,777	n/a	n/a
Land Acq.	1996	$29,000	$-	$29,000	$-	$29,000	$40,310	n/a	n/a
Land Acq.	1997	$7,260	$-	$7,260	$-	$7,260	$9,874	n/a	n/a
Land Acq.	1998	$321,100	$-	$321,100	$-	$321,100	$430,274	n/a	n/a
Land Acq.	1999	$-	$-	$-	$-	$-	$-	n/a	n/a
Land Acq.	2000	$530	$-	$530	$-	$530	$673	n/a	n/a
Land Acq.	2001	$11,217	$-	$11,217	$-	$11,217	$13,797	n/a	n/a
Land Acq.	2002	$-	$-	$-	$-	$-	$-	n/a	n/a
Land Acq.	2003	$1,962	$-	$1,962	$-	$1,962	$2,335	n/a	n/a
Land Acq.	2004	$42	$-	$42	$-	$42	$48	n/a	n/a
Land Acq.	2005	$2,292	$-	$2,292	$-	$2,292	$2,567	n/a	n/a
Land Acq.	2006	$2,033	$-	$2,033	$-	$2,033	$2,196	n/a	n/a

Table 3. FWS and Florida FFWCC spending on Florida scrub-jay conservation *continued*

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	In 2010 $	Notes	Source
Land Acq.	2007	$10,900	$-	$10,900	$-	$10,900	$11,445	n/a	n/a
Land Acq.	2008	$2,670	$-	$2,670	$-	$2,670	$2,697	n/a	n/a
Land Acq.	2009	$51,400	$2,500,000	$2,551,400	$-	$2,551,400	$2,602,428	n/a	n/a
Project	2004	n/a	n/a	n/a	$30,000	$60,000	$69,000	Lake Wales Ridge Prescribed Fire Strike Team; 2005-2007	FFWCC
Project	2005	n/a	n/a	n/a	$49,210	$98,420	$110,230	Lake Wales Ridge Prescribed Fire Strike Team; 2007-2008	FFWCC
Project	2007	n/a	n/a	n/a	$42,303	$84,605	$88,835	Lake Wales Ridge Prescribed Fire Strike Team; 2008-2009	FFWCC
Project	2009	n/a	n/a	n/a		$390,754	$398,569	Experimental Restoration of Florida Scrub on the Lake Wales Ridge; 2009-2012	FFWCC
Project	1995	n/a	n/a	n/a	$5,000	$15,000	$21,450	Florida Scrub HCP-II The Nature Conservancy - Florida	NFWF

Table 3. FWS and Florida FFWCC spending on Florida scrub-jay conservation *continued*

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	In 2010 $	Notes	Source
Project	1999	n/a	n/a	n/a	$15,000	$45,000	$58,950	Florida Scrub Interagency Fire Strike Team The Nature Conservancy	NFWF
Project	2001	n/a	n/a	n/a	$15,000	$45,000	$55,350	Florida Scrub Interagency Fire Strike Team-II The Nature Conservancy	NFWF
Project	2002	n/a	n/a	n/a	$96,350	$201,959	$244,370	Florida Scrub Jay Habitat Restoration Hillsborough County Resource Management	NFWF
							$28,779,302		

Sources: U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission and National Fish and Wildlife Foundation. n/a = no additional data

Table 4. FWS and Florida FFWCC spending on Florida gopher tortoise conservation

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Non-Land	1994	$69,000	$98,500	$167,500	$100	$167,600	$246,372	n/a
Non-Land	1995	$21,700	$135,560	$157,260	$-	$157,260	$224,882	n/a
Non-Land	1996	$74,000	$154,980	$228,980	$5,000	$233,980	$325,232	n/a
Non-Land	1997	$30,000	$840,000	$870,000	$8,000	$878,000	$1,194,080	n/a
Non-Land	1998	$158,500	$264,000	$422,500	$-	$422,500	$566,150	n/a
Non-Land	1999	$102,500	$235,010	$337,510	$4,500	$342,010	$448,033	n/a
Non-Land	2000	$135,000	$310,510	$445,510	$56,500	$502,010	$637,553	n/a
Non-Land	2001	$153,000	$282,800	$435,800	$82,500	$518,300	$637,509	n/a
Non-Land	2002	$178,000	$622,200	$800,200	$85,000	$885,200	$1,071,092	n/a
Non-Land	2003	$293,000	$2,009,195	$2,302,195	$82,500	$2,384,695	$2,837,787	Population west of Mobile/ Tombigbee Rivers
Non-Land	2004	$109,500	$1,944,600	$2,054,100	$48,000	$2,102,100	$2,417,415	Population west of Mobile/ Tombigbee Rivers
Non-Land	2005	$157,500	$1,974,600	$2,132,100	$-	$2,132,100	$2,387,952	Population west of Mobile/ Tombigbee Rivers
Non-Land	2006	$56,500	$13,291,959	$13,348,459	$-	$13,348,459	$14,416,336	Population west of Mobile/ Tombigbee Rivers
Non-Land	2007	$43,000	$3,019,826	$3,062,826	$15,220	$3,078,046	$3,231,948	Population west of Mobile/ Tombigbee Rivers
Non-Land	2008	$48,000	$386,751	$434,751	$9,650	$444,401	$448,845	Population west of Mobile/ Tombigbee Rivers
Non-Land	2009	$153,500	$845,978	$999,478	$1,492	$1,000,970	$1,020,989	Population west of Mobile/ Tombigbee Rivers
Land Acq.	1994	$-	$-	$-	$-	$-		n/a
Land Acq.	1995	$-	$-	$-	$-	$-		n/a
Land Acq.	1996	$-	$-	$-	$-	$-		n/a
Land Acq.	1997	$-	$-	$-	$-	$-		n/a
Land Acq.	1998	$-	$-	$-	$-	$-		n/a
Land Acq.	1999	$485,000	$-	$485,000	$-	$485,000	$635,350	n/a
Land Acq.	2000	$1,562,000	$-	$1,562,000	$-	$1,562,000	$1,983,740	n/a
Land Acq.	2001	$832,000	$486,500	$1,318,500	$-	$1,318,500	$1,621,755	n/a

Table 4. FFWCC spending on Florida gopher tortoise conservation *continued*

	Year	FWS	Other Fed	Fed Total	State Total	Species Total	in 2010 $	Notes
Land Acq.	2002	$51,000	$-	$51,000	$1,400,000	$1,451,000	$1,755,710	n/a
Land Acq.	2003	$-	$480,000	$480,000	$-	$480,000	$571,200	Population west of Mobile/ Tombigbee Rivers
Land Acq.	2004	$-	$-	$-	$-	$-	$-	Population west of Mobile/ Tombigbee Rivers
Land Acq.	2005	$13,125	$-	$13,125	$-	$13,125	$14,700	Population west of Mobile/ Tombigbee Rivers
Land Acq.	2006	$-	$-	$-	$-	$-	$-	Population west of Mobile/ Tombigbee Rivers
Land Acq.	2007	$-	$181,000	$181,000	$-	$181,000	$190,050	Population west of Mobile/ Tombigbee Rivers
Land Acq.	2008	$-	$-	$-	$-	$-	$-	Population west of Mobile/ Tombigbee Rivers
Land Acq.	2009	$-	$731,000	$731,000	$-	$731,000	$745,620	Population west of Mobile/ Tombigbee Rivers

Sources: U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission and National Fish and Wildlife Foundation. n/a = no additional data