The Economic Value of Ecosystem Services in Four Counties in Northeastern Florida

A companion report to the study *Economic Benefits of Natural Land Conservation: Case Study of Northeastern Florida*, commissioned by Defenders of Wildlife from C. Kiker and A. Hodges (2002)

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Executive Summary

The ecosystems that make up the landscapes in the four northeast Florida counties of Clay, Duval, Putnam, and St. Johns provide a large variety of services that directly or indirectly enter the local economy. In economic terminology, these services commonly are referred to as ecosystem function services. Ecosystem function services contribute to economic output, commonly measured as gross production (for example, on the national level, the familiar gross domestic product, or GDP). Therefore, they carry an economic value in proportion to their contribution to that output.

Unfortunately, the economic value of the services provided by ecosystems is rarely accounted for in analyses of local or regional economies. This is despite the fact that in economics, specifically in the subfields of natural resource and environmental economics, a variety of approaches have been developed to quantify the monetary value of such services, and a considerable number of studies have been carried out that estimate the value of particular service functions for particular ecosystems. Although most of these value estimates are context specific, that is, they depend on the particular location of the ecosystem that provides the services, they can be used to develop estimates of the service value provided by similar ecosystems in other locations.

Several of the service values provided by the ecosystems found in the four northeast Florida counties have been quantified in the literature. Although the values of many other services provided by these ecosystems remain yet to be quantified, applying the unit value estimates that are available reveals an estimated total economic value of ecosystem services in the four-county area of approximately $3.2 billion per year. Because this amount excludes the value of a considerable number of services provided by many ecosystem types, it is likely to be a substantial underestimate.[1] Nevertheless, the estimated value of these ecosystem services is equivalent to four and a half times the total economic value of all outdoor recreation in the four counties, and is equivalent to eleven percent of the value of total market-traded output of the area (the gross county product), or to 26 percent of the combined output of the agriculture, mining, construction, and manufacturing sectors of the four counties. Interestingly, the estimated economic value of the ecosystem services in the four-county area is larger than the sum of the direct use and non-use values of the ecosystems, which has been estimated at $2.6 billion per year (Kiker and Hodges, 2002).

[1] For example, the value of most services provided by shrub and brushlands is unknown, as is the value of soil formation, biological control, nutrient cycling, and climate regulation services provided by most of the ecosystem types found in the study area.

Introduction

It is by now well recognized that ecosystems, and the habitats and wildlife they contain, hold a variety of economic values for society. These values are associated with the direct use of ecosystem products, indirect use of ecosystem services, and non-use of species and habitats. Examples of direct use of ecosystem outputs are timber extraction, recreation, and water withdrawal. Indirect use occurs in the form of appropriation of ecosystem services that serve as inputs for, and often make possible at all, human production of goods and services (Daily et al., 1997; Balmford et al., 2002). Services performed by ecosystems include maintenance of hydrological and nutrient cycles, soil formation and erosion control, pollination, habitat provision, nursery for fish and game species, provision of food and water for humans and livestock, climate regulation, disturbance regulation, waste management, and biological control. Finally, non-use values include existence, stewardship, bequest, and option values, which individuals attach to knowing that particular species and habitats exist and are passed on to posterity, even though they may never come into contact with the species or habitats (Krutilla, 1967; Kramer et al., 2002). Direct use, indirect use, and non-use values together make up the total economic value of these systems.

In a recent study, the value of the economic benefits generated by the natural landscapes of four counties in northeastern Florida was estimated at $2.6 billion per year (Kiker and Hodges, 2002).[2] The two categories of economic values captured in this estimate are the direct use values and the non-use values associated with agricultural and forest products extracted from the lands, recreational activities carried out on the lands, and environmental amenities and quality of life provided by the lands. The amount of value added from the market-traded products associated with the agricultural and forest industry activities taking place on the lands was approximately $440 million per year, while the total economic value of recreation-related activities on the lands was estimated at $703 million per year ($390 million in consumer expenditures and $313 in consumer surplus). Further, using a benefit transfer approach and employing very conservative estimates (10 percent or less of the respective values reported in the source studies used by the authors), the authors put the aggregate consumer surplus from the environmental amenities and the quality of life provided by the lands in the study area at approximately $1.5 billion per year. This value captures the willingness to pay of people for the benefits they receive from visual and other amenities provided by the lands and likely represents primarily the direct use value to residents, but to a lesser degree also non-use values.

In their report, the authors also provide a comprehensive list of the services ecosystems provide to society (Kiker and Hodges, 2002: 26-27). However, they do not attempt to develop an estimate of the monetary value of those services.

The aim of the present companion report is to develop such an estimate of the economic value of the ecosystem services generated by the most prominent ecosystem types found in the four northeast Florida counties examined by Kiker and Hodges.

Defining ecosystem services

Landscapes contain ecosystems, and like all systems, they are characterized on a fundamental level by their structure and function (Odum, 1962). The structure comprises the constituent components of a system, that is, its biotic and abiotic elements, while function comprises the activities of these elements. By way of a metaphor, we may think of the structure as stocks, such as populations of species, soil, and water, and of the function as flows. Examples of flows are the nutrients and water

[2] The counties included in the analysis were Clay, Duval, Putnam, and St. Johns.

that cycle between the elements of the system, or the creation of soil through the weathering of bedrock.

Both stocks and flows of natural systems are objects of assigned values. These assigned values are context-specific, that is, they depend upon social preferences and individuals' economic circumstances. Some categories of economic values apply mostly to the structure, or stocks, of the system, as is the case for direct use, option, and non-use (existence, stewardship, bequest, and intrinsic) values; the third value category, indirect use values (ecosystem service or function values) generally applies to flows. The total economic value of a natural system is the sum of all use values (direct, indirect, and option) and non-use values (see Fig. 1).[3]

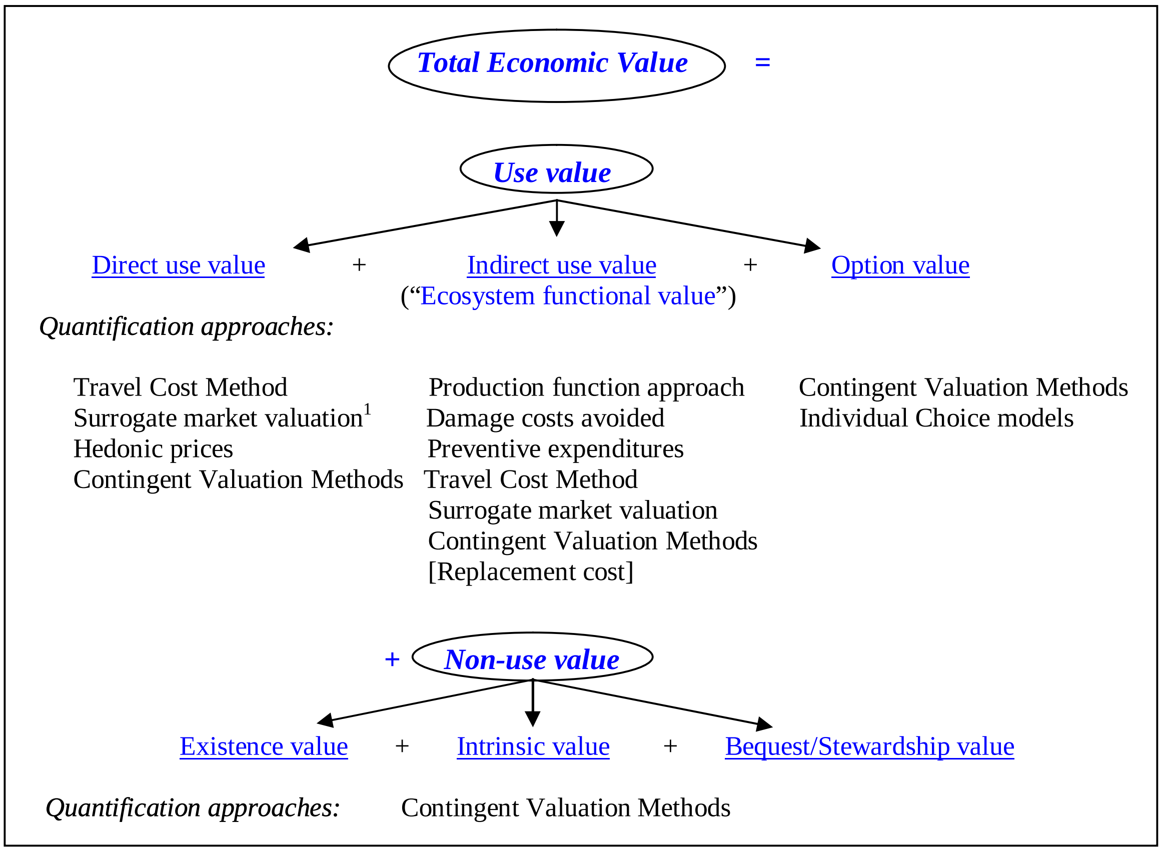

Figure 1: Categories of economic values of ecosystems and available valuation approaches
Notes: [1] Household production function models. Replacement cost is in brackets because its use in ecosystems valuation in many cases is problematic.
Source: Based on Barbier (2000).

Ecosystem (function) services are those outputs of the operations of natural systems that carry direct economic value, that is, products that contribute to economic output (marketed or not) and individuals'

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[3] Existing gaps in our understanding of the functioning of complex natural systems such as landscape-level ecosystems often still prevent the full specification of most quantitative models of ecosystem functioning. This in many cases prevents an exact identification of the specific contribution of the various system components to particular system outputs (the provision of ecosystem services), and, hence, the assigning of ecosystem service value to those specific components. As long as the outputs of the total system can be measured, however, limited knowledge of a systems' functioning does not preclude the valuation of the services (i.e., its output) rendered by the system as a whole.

well-being. An example of ecosystem services is a wetland serving as a natural water "filter", taking up and processing many forms of water pollution from agricultural run-off and other sources, and as a result improving local water quality. Wetlands also provide important regulation services in the local water cycle, and they buffer the impacts of both droughts and flood events.

Most analyses of the total economic value of the goods and services produced in a geographic area ignore ecosystem service values. Instead, economic analyses commonly focus on human-produced goods and services only. This often generates grave misperceptions as to how human economies and societies function. For example, gross domestic product (GDP) is a measure of the economic value of the totality of goods and services produced in a country in a given year. GDP measures the market value of the output of the national economy. Presently, only human-produced goods and services are accounted for in GDP. However, all of the goods and services produced in society's economic activities are directly or indirectly dependent upon services and material and energy inputs provided by ecosystems (see Figure 2). To give but two examples, coral reefs and coastal wetlands serve as spawning grounds and nurseries for many fish species that support commercial and recreational fisheries. Wetlands thus provide important inputs to the economic production of the fishing sector.

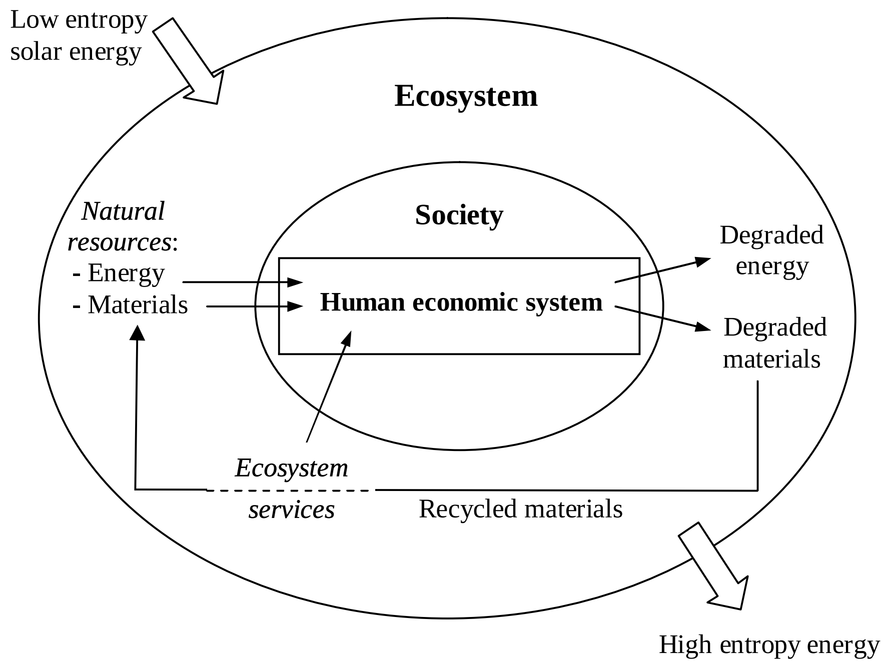

Figure 2: Diagram of the basic operation of the human economic system from an ecological perspective (adapted from Hall et al. (1986) and Cleveland and Ruth (1997))

Ignoring the essential contribution of ecosystems to the output of the human economy would not constitute much of a problem if society's activities would not impact on a grand scale the ecosystems upon which these very activities depend. But that is not the case. Rather, ecosystems continuously are being appropriated and otherwise impacted by human society through economic growth and increasing human populations.[4] It was the realization of these impacts that led to the rise of the modern conservation movement in the United States and the enactment of major environmental and

[4] Due to the scale of human activity, by now all of the earth's ecosystems are impacted in some form by the consequences of human actions. Hence all ecosystems are either human-affected or human-dominated. (Vitousek et al., 1997; McCarthy et al., 2001).

conservation laws, such as the National Environmental Policy Act (NEPA) and the Endangered Species Act (ESA), as well as the creation of agencies like the Environmental Protection Agency (EPA) and the Natural Resource Conservation Service (NRCS).[5]

Some of the services provided by ecosystems may also be provided by human-engineered systems. For example, a wastewater treatment plant can fulfill filtering functions similar to those provided by a wetland. However, such artificial "replacements" of ecosystems are not true equivalents of their natural counterparts, because human systems are generally unifunctional, while natural systems have multi-attribute character. A water treatment plant may approximate the filtration activities of a wetland, but it cannot replace most of the other functions a wetland provides (fish nursery, disturbance regulation etc.). The fundamental importance of ecosystems for human societies derives from this lack of functional equivalence in the services provided by human-produced and natural capital. It is evident, therefore, that ecosystems, though rarely considered in an economic context, are vitally important for all human economies, as they provide a wide variety of goods and services to society.

A variety of approaches exist for quantifying the economic value of ecosystem services (see Fig. 1). However, there still are many ecosystem types for which service values so far have not yet been quantified. This is due to the large variety of functions performed by ecosystems and the often very complex studies needed to estimate quantitatively the physical flows associated with these services, as well as the monetary values of these services.

The major ecosystem types found in the four Florida counties examined by Kiker and Hodges (2002) are shown in Table 1, together with their respective total spatial extents, that is, the total area covered by a particular ecosystem type. Figure 2 shows a map of the four-county area and its land cover characteristics.

Table 1: Total areas of the most prominent ecosystem types found in four counties included in Florida study

Ecosystem type	*Area*
	hectares
Freshwater marshes	8,258
Bay swamps	3,306
River/lake swamp	22,911
Saltwater marsh	20,213
Bays and estuaries	27
Lakes	16,447
Streams and waterways	51,736
Mixed shrub-shrub wetland	12,566
Wetland coniferous forests	11,569
Wetland forested mix	88,175
Mixed wetland hardwoods	6,653
Wet prairies	2,922
Forest regeneration	57,650
Hardwood-conifer mixed	39,618
Shrub and brushland	11,777
Total	353,828

Source: Kiker and Hodges (2002)

[5] The NRCS for example administers the Wetlands Reserve Program (WRP) and the Grassland Reserve Program (GRP).

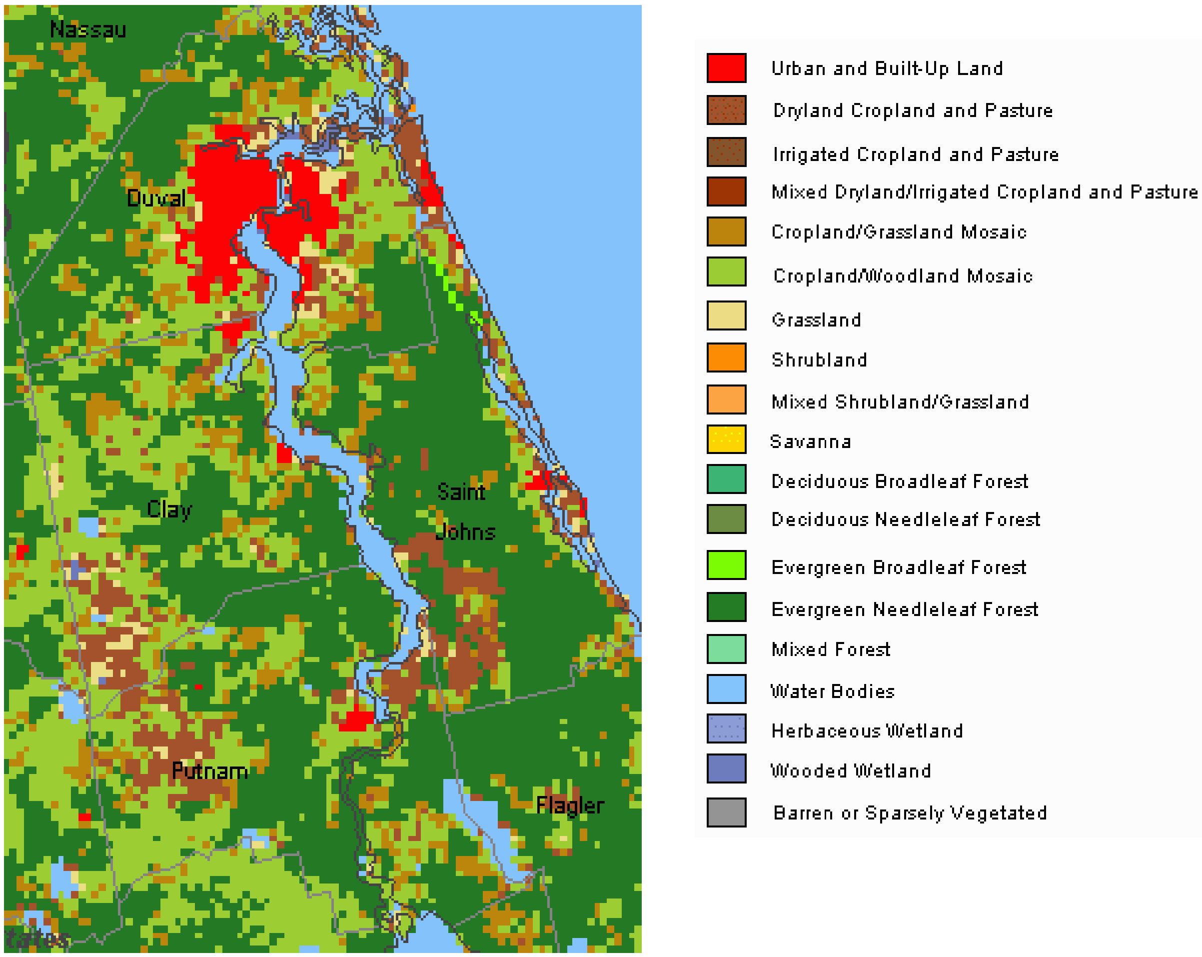

Figure 2: Land cover characteristics of the four-county area
Source: EROS Data Center, U.S. Geological Survey (2002)

Methodology

The objective of this study is to develop a first approximation of the economic value of the ecosystem services provided by the natural systems in the four north Florida counties. Given this objective, we do not develop original, site-specific value estimates. Such estimates would require the actual physical measurement of the various service flows provided by the ecosystems in the four counties, as well as a detailed analysis of the use of these flows by the human systems in the study area. Rather, we use estimates reported in the literature of the average per-acre values of specific services provided by the major ecosystem types. We apply these estimates to the ecosystems in our study area in a simple benefits transfer. Benefits transfer commonly is defined as the adaptation of value estimates generated at a study site to another site (the “policy site”) for which such estimates are desired but no primary data for their generation are available (Rosenberger and Loomis, 2001).

Due to gaps in the literature, our value estimates do neither cover all services nor all ecosystem types found in the four counties. For example, the economic values associated with biodiversity maintenance, pollination, nursery function, and raw materials provision are not included due to a lack of data for the ecosystems found in our study area. In addition, there are a number of service values that are available only for some of the ecosystem types found in the four counties, but not for others.

Estimates of the economic values of the various ecosystem services provided in the four county area are based on a variety of direct and indirect market valuation approaches, or, in the case of contingent valuation, on simulated (hypothetical) markets (see Table 2).

Table 2: Approaches used in the valuation of ecosystem services

Ecosystem function	*Valuation approach* [1]
Gas regulation	AC
Climate regulation	AC
Water regulation	FI/AC
Water supply and in-stream recreation	MP/CV [2]
Disturbance regulation	AC/RC
Nutrient cycling	RC
Soil retention	AC/RC
Soil formation	AC
Waste treatment	RC/CV
Habitat/refugium provision	MP/CV
Biological control	RC/FI/MP
Food production	MP/FI/CV

Notes: [1] Information on primary valuation method from de Groot et al. (2002): AC - avoided cost; RC - replacement cost; CV - contingent valuation; FI - factor income; MP - market price. [2] Various uses (off-stream, hydroelectric generation, recreation) valued using different methods (U.S. Forest Service, 2000).

A comprehensive list of ecosystem services provided by the ecosystems in the study area and their economic values is given in Table 3. The total value of the services provided by a particular ecosystem type in the study area is estimated by multiplying the per-acre values of specific ecosystem services provided by a particular ecosystem type by the total acreage in the study area occupied by that ecosystem type.

Because the service function values of wetlands and forests differ substantially (see Table 3), the area identified in Table 1 as “wetlands forested mix” was assigned in equal parts to “wetlands” and “hardwood-conifer mixed”.

Table 3: Estimated values of the most important ecosystem service functions for selected ecosystem types found in northern Florida

Ecosystem type	*Value of ecosystem services, by service function; 2002$/ha/yr*										
	Gas regulation	*Climate regulation*	*Disturbance regulation*	*Water regulation*	*Water supply*	*Soil formation*	*Nutrient cycling*	*Waste Management*	*Biological control*	*Habitat/ Refugia*	*Food production*
Freshwater marshes	322	n.a.	8,789	36	9,226	n.a.	n.a.	2,014	n.a.	533	57
Bay swamps	322	n.a.	8,789	36	9,226	n.a.	n.a.	2,014	n.a.	533	57
River/lake swamp	322	n.a.	8,789	36	9,226	n.a.	n.a.	2,014	n.a.	533	57
Saltwater marsh	322	n.a.	2,232	36	9,226	n.a.	n.a.	8,128	n.a.	205	566
Bays and estuaries	n.a.	n.a.	688	n.a.	n.a.	n.a.	25,613	n.a.	95	159	632
Mixed shrub-shrub wetland	161		5,510	18	4,613	n.a.	n.a.	n.a.	n.a.	369	311
Wetland coniferous forests	161		5,510	18	4,613	n.a.	n.a.	n.a.	n.a.	369	311
Wetland forested mix*	161/0	0/171	5,510/n.a.	18/0	4,613/45	n.a./12	n.a./438	n.a./106	n.a./5	369	311
Mixed wetland hardwoods	161		5,510	18	4,613	n.a.	n.a.	n.a.	n.a.	369	311
Wet prairies	161		5,510	18	4,613	n.a.	n.a.	n.a.	n.a.	369	311
Forest regeneration	n.a.	171	n.a.	n.a.	45	12	438	106	5	n.a.	61
Hardwood-conifer mixed	n.a.	171	n.a.	n.a.	45	12	438	106	5	n.a.	61
Shrub and brushland	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.

Notes: Values taken from Costanza et al. (1997), except for water supply by forest systems, which are from U.S. Forest Service (2000). Values given by sources were adjusted to 2002 prices using the Consumer Price Index (Council of Economic Advisors, 2003). n.a. indicates data are unavailable. * Values in each cell are for wetlands and temperate forests, respectively (“wetlands”/”temperate forests”).

Results

The total annual economic value of the services provided by the ecosystems in the four northern Florida counties is substantial. Although not all ecosystem functions could be included in the analysis, the total value of those that were included is estimated at approximately $3.2 billion per year (see Table 4). This amount is equivalent to four and a half times the total annual economic value of all outdoor recreation in the four counties, eleven percent of the annual value of total market-traded output of the area, or 26 percent of the combined annual output of the agriculture, mining, construction, and manufacturing sectors of the four counties (see Kiker and Hodges, 2002). Interestingly, it is also larger than the sum of the direct use and non-use values of the ecosystems, estimated by Kiker and Hodges at $2.6 billion per year.

Table 4: Estimated annual value of ecosystem services provided by major ecosystem categories in four northeast Florida counties

	million 2002$/ year
Marshes, swamps, lakes, rivers, streams, estuaries	1,827
Wetlands	1,249
Forests	118
Total	3,194

Notes: Values are for acreages shown in Table 1.

Discussion

The findings of this analysis make obvious the scale of the economic importance of the services provided by natural systems. The total economic value of the annual flow of services provided by the natural ecosystems in the four-county area could be approximated by adding the total ecosystem service value presented in Table 4 to the direct use and non-use values presented by Kiker and Hodges (2000).[6] However, some of the ecosystem service values estimated in this analysis may already be captured in Kiker and Hodges' study, to the extent that Kiker and Hodges' recreation value estimates may include the direct use and non-use components of the habitat/refugium values, and to the extent that the food production service value is captured in the output of the agricultural sector. The habitat/refugium and food production service values account for only four percent of the total ecosystem service value (see Table 3). Even if these values are excluded from the analysis to avoid double-counting when summing the estimates presented in this study with those derived by Kiker and Hodges, the total economic value of the ecosystem services in the study area is still $3.07 billion per year. The total economic value of the natural systems is estimated at over $5.7 billion per year.

Perhaps the most striking result of the present analysis is that of the economic value associated with the ecosystem services ($3.2 billion per year) in the four-county area is larger than the sum of the direct use and non-use values of these systems, estimated by Kiker and Hodges (2002) at $2.6 billion per year. Given that both their analysis and the estimate presented in this analysis necessarily are characterized by uncertainties, it is not possible to state with certainty that the service value of the ecosystems in the four-county area surpasses the sum of the direct and non-use values. Nevertheless, it seems safe to assume that the indirect use (i.e., the ecosystems

[6] As discussed above, the total economic value of a good is the sum of direct use, indirect use (i.e., ecosystem service), and non-use values of the good.

function) value is comparable in size to the sum of the direct use and non-use values provided by these systems.

As discussed in the methods section, we derive our estimate of the total economic value of the services provided by the ecosystems in the four-county area in northern Florida using average per-acre values of specific ecosystem services reported in the literature. Using average values to derive the total annual value of ecosystem services over the entire four-county area may be problematic if the economy in the four-county area were to collapse in case all natural areas and the ecosystem services provided by these were lost. If the latter were the case, the total value of these areas to that regional economy would not be over three billion dollars per year, but rather would be infinite. However, since the spatial extent of the area is quite small, and since the economy under consideration could to some extent draw on ecosystems beyond its boundaries and on manufactured capital to substitute specific lost local ecosystem services, it is unlikely that the loss of the majority of the ecosystems would lead to the total collapse of the local economy.[7] In other words, the scale of our analysis is sufficiently small to justify our use of the average marginal values of ecosystem services taken from the literature. Nevertheless, the complete loss of the ecosystem services in the four counties likely would necessitate substantial compensatory adjustments. These would take the form of human-engineered systems that would replicate some of the most desired service functions otherwise provided by the natural ecosystems. If the relative magnitude of the hypothetical loss of ecosystem services in the four-county area would exceed the average magnitude of the loss examined in the source studies, then the per-unit values of these services would be expected to be higher in our case than in the source studies. In that case, our total annual value estimates for the four-county area would be biased downward. A much more detailed analysis would be required to compare the relative magnitude of the ecosystem service loss in our case and in the source studies.[8]

One must also be aware that the service values used in this analysis (see Table 3) were not developed for the four-county area in question, but for other areas. Some service values depend, among other factors, on the proximity of the respective ecosystems to locations of human activity and to levels of particular types of pollution. In addition, all service values depend on the size of the affected economy and the relative scarcity of the particular ecosystem services. Therefore, some of the values used may not be accurate estimators for the actual values provided by the ecosystems in the four Florida counties. To the extent that this is true in the case at hand, the application of benefit transfer will result in errors in our value estimates. Ideally, to avoid such errors, a more detailed analysis of the local context would be required (IUCN, TNC, and World Bank, 2004). For these reasons, the estimated total annual value of the ecosystem services provided by the natural areas in the four north Florida counties should only be considered only a rough approximation.

It is worth pointing out that the per-acre values in Table 3 represent averages of the marginal values of ecosystem services in specific locales and points in time. The marginal value of an acre of a specific ecosystem changes with the existing quantity of acres of that ecosystem, among other things. The distinction between average and marginal values is of importance in assessing the economic benefits of land conservation vs. land conversion. While the values given in Table

[7] If the analysis focused on the national economy instead, this would not be the case, as such substitution possibilities decrease with an increase in the size of the area analyzed.

[8] The magnitude of the loss is the ratio of the ecosystem services consumed by the local human economy that are provided by the ecosystem in question (in our case, those in the four-county area) to the total of all ecosystem services used by that economy (i.e., those provided from natural systems in the area and from systems outside of the four-county area).

3 are assumed to approximate the economic benefits generated by an acre of wetland in the present, the value of an acre of wetland is likely to increase with a continuing reduction in total wetland acreage. Therefore, using average values of wetland ecosystem services based on current conditions of wetland extension to assess the relative economic attractiveness of ecosystem conversion is misleading as a basis for decisions about future conversions. For example, assuming that under present conditions it were the case that the average economic value of converting an acre of wetland was higher than the average value of all the ecosystem services provided by that acre, this would seem to justify the conversion of wetlands. However, with each additional acre of natural wetlands lost, the marginal ecosystem service value, that is, the value per-acre of the remaining wetlands, will be higher than the value of an acre under "current" conditions, that is, under the present extension of wetlands (see also Bulte and Van Kooten, 2000). The steeper the slope of the marginal value function, the faster the point will be reached at which the benefits of conserving an acre of wetland would be larger than the benefits of converting that acre.

Conclusion

Ecosystems provide a large variety of services that are instrumental to the functioning of society's economic system. These services carry real economic value. Unfortunately, this value often goes unrecognized, because the links between ecosystem functioning and the economic well-being of society often are not self-evident to the casual observer.

Because of the very real economic importance of ecosystems, it is imperative that policy decisions take into account the economic value generated by ecosystems. This is often not an easy task, because the interactions between the economic system and the ecosystem in which it is embedded are characterized by a high degree of complexity. Due to this complexity, approaches that aim to quantify the economic importance of ecosystem services are still very much under development. However, the importance of quantifying the contribution of ecosystems to society's well-being has been well recognized in the academic and research communities, and the issue is now very much at the forefront of interdisciplinary research in the fields of ecosystem science and natural resources and ecological economics. However, even though our abilities to quantify the economic value of ecosystem services are still evolving, the current state of knowledge is sufficiently advanced to permit the generation of estimates to inform decision-making. Such information is sorely needed, as the consideration of the economic value of ecosystems in land use policy-making is likely to result in better decisions and improved choices. This paper presents a simple approach for achieving that goal, by employing available information to develop estimates of the economic value of ecosystem services for a four-county area in northeastern Florida.

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