Market and Nonmarket Values of the Georgia Landscape

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ABSTRACT / Natural landscapes produce goods and services, such as fish, wildlife, recreation, climate control, that are not adequately incorporated in their market values. Contingent Valuation (CV) and Energy Analysis (EA) approaches were used to estimate the nonmarket value of forests in Georgia. Both methods yielded similar estimates of approximately $200 ha⁻¹, which was 31% of the total market and nonmarket value of forests. Energy analysis was also used to estimate the nonmarket value of the major land uses in Georgia. Relative contributions of nonmarket value to total value ranged from 0.1% for urban areas to approximately 100% for wetlands. For the state as whole, nonmarket production of natural and developed ecosystems was estimated at $2.8 billion. This value is comparable to annual marketed agricultural ($2.8 billion) and timber ($4.5 billion) production, both very important industries in Georgia. Changing land use patterns in Georgia and elsewhere are likely to be accompanied by shifts in the relative importance of market and nonmarket values.

The value of natural lands and waters is not adequately reflected in their market prices. A fundamental reason for this is that the services of natural areas (and to a lesser extent agricultural [Bergstrom and others 1985] and urban areas) are imperfectly owned. The owners of the areas cannot charge others adequately for all the positive services they provide, nor prevent others from benefiting from these services. The nonmarketed values may be quite large, but they must be measured indirectly (Delorme and Wood 1974) and are difficult to determine with any exactness (Westman 1977, Healy 1985). Therefore, environmental services have historically been grossly undervalued (Alig 1983). The lack of precise empirical data for measuring all environmental and wildlife values tends to result in superficial consideration of intangible and qualitative values and greater emphasis on values measurable in monetary terms, even though these may be negligible in comparison (Van Dieren and Hummelink 1979, Kellert 1984). Valuation of the benefits of nonmarketed resources and services in natural areas has therefore been identified as a major research need (e.g., Odum 1975 and 1977, Westman 1977, Alig 1983, Loomis and Hof 1985, Loomis and Walsh 1986).

As the intensity of use of many habitats increases, some types of natural land may become scarce, and resources that should be renewable may sustain damage (Healy 1985). Land use patterns have been changing rapidly in the southeastern United States during the past several decades (cf. Nelson 1957, Breider 1974, Healy 1985, Turner 1987). Changing demands have led to greater competition in allocating increasingly scarce land resources (Alig 1983). However, most land use decisions do not consider impacts on nonmarketed values. Faced with the rapid development occurring in the region, we think it is important to evaluate and compare the nonmarket and market values of habitats.

As part of a landscape-level study of Georgia (southeastern USA) we identified the nonmarket value of forest and other natural lands within the state. In this article, we (1) compile and review previous contingent valuation method estimates of recreation and wilderness values of Georgia forests; (2) estimate the value of forest lands based on energy analysis; and (3)

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compare these two nonmarket value estimates with each other and with the market value of forest lands and other lands; and (4) estimate the total value of Georgia using energy analysis and compare this value with market values.

Valuation Methods

There are several methods of economic valuation of nonmarket benefits (see, for example, Westman 1977, Bernstein 1981, Brookshire and Crocker 1981, Brookshire and others 1982, Kellert 1984, Costanza and Farber 1984, Daly 1984, Loomis and Walsh 1986). Two broad groups include the Contingent Valuation (CV) approach and the Energy Analysis (EA) approach.

The CV method seeks to measure nonmarket values by determining what people would be willing to pay for natural resources and services if a suitable market existed. The US Water Resources Council (1979) approved the CV method as a procedure for estimating the economic value of recreational and environmental resources. Using surveys and questionnaires, pseudomarkets can be constructed to estimate the value of nonmarketed services. Loomis and Walsh (1986) argue that CV is (at least in principle) an adequate means to empirically estimate a consumer's option, existence, bequest, and recreational values of a particular wildlife species or natural area (Weisbrod 1964, Kruitilla 1967, Walsh and others 1984). Schulze and others (1981) report that the most readily applicable economic methodologies for evaluating recreation values all yield estimates within one order of magnitude of each other. Even small values per household result in substantial national or regional values (Stoll and Johnson 1984).

The problems with this approach are: (1) it relies on consumers' current preferences and level of knowledge of natural areas (which may be improving but is far from adequate); (2) it must add all the incremental values of the individual services provided by a natural area, and important functions may be omitted or underestimated; (3) it is often difficult to assure honest answers to questions on surveys, since people have a subconscious tendency to tell the questioners what they think they want to hear; and (4) it does not represent an actual transaction.

Energy Analysis (EA) is another approach to the valuation of natural areas that is philosophically more biological and more holistic. It concentrates on the relationships within natural systems that lead to the production (supply) of natural services, rather than human demand for natural system products (Costanza and Farber 1984). The method considers the total amount of energy captured by natural ecosystems as an estimate of their potential to do useful work for society. The critical link in using energy analysis for nonmarket valuation is the relationship between the energy embodied in the system and its economic value, and this relationship is still controversial (e.g., Costanza 1980 and 1984, Daly 1981, Huitker 1982, Costanza and Herendeen 1984, Cleveland and others 1984). However, even with this uncertainty, the EA estimate is a useful check on the economic value of natural systems derived from the CV method, which also contains considerable uncertainty.

Contingent Valuation and Energy Analysis methods were compared and evaluated by Costanza and Farber (1984) and have been used jointly to estimate wetland values in Louisiana (Farber and Costanza 1987). The major difference between them is that CV is based on human demand or benefit, whereas EA is based on natural system supply, or cost, including the cost to the natural system for resource production. They represent alternative approaches to incorporating existing information about the environment into nonmarket valuation.

Nonmarketed Natural System Values

Recreation and Wilderness Values

The most extensive studies of nonmarket natural system values have focused on recreation, wildlife, and wilderness-related values. Here we review studies that are applicable to the southeast and Georgia. Outdoor recreation is usually not marketed but is provided as a joint product with other land uses or as a government service (Musser and others 1982). Sorg and Loomis (1982) reviewed a variety of recreation benefits estimated by different methodologies. Their results indicate that recreation values were fairly consistent when the methodological assumptions and dates of the studies were standardized. Differences in value could largely be explained by differences in resource quality and relative location from user populations.

A set of recreation and wilderness value estimates for forests were compiled for the US Forest Service by Loomis and Sorg (1982) as part of the Resource Planning Act (RPA) process. The objective was to derive forest values for each of the nine Forest Service regions. Loomis and Sorg collected data from published and unpublished sources that used either CV or travel cost methods to estimate a variety of forest values (Table 1). Data were adjusted to account for methodological differences and were converted to standard
Table 1. Recreational activity values for national forests in the southern region, and for the Chattahoochee and Oconee National Forests, Georgia.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Southern regiona</th>
<th>Georgia b</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cold water fishing</td>
<td>13.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Warm water fishing</td>
<td>24.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fishing, average all types</td>
<td>18.50</td>
<td>29.38</td>
<td>23.94</td>
</tr>
<tr>
<td>Big-game hunting</td>
<td>40.00</td>
<td>35.79</td>
<td></td>
</tr>
<tr>
<td>Small-game hunting</td>
<td>28.00</td>
<td>31.31</td>
<td></td>
</tr>
<tr>
<td>Waterfowl hunting</td>
<td>25.00</td>
<td>45.00</td>
<td></td>
</tr>
<tr>
<td>Upland game hunting</td>
<td>40.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hunting, average all types</td>
<td>33.25</td>
<td>46.03</td>
<td>39.64</td>
</tr>
<tr>
<td>Motorized travel</td>
<td>11.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Camping</td>
<td>16.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Picnicking</td>
<td>10.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developed recreation, average all types</td>
<td>12.34</td>
<td>6.21</td>
<td>9.27</td>
</tr>
<tr>
<td>Hiking</td>
<td>20.00</td>
<td>11.90</td>
<td>15.95</td>
</tr>
<tr>
<td>Wilderness</td>
<td>25.00</td>
<td>25.96</td>
<td>26.98</td>
</tr>
<tr>
<td>Average of all types</td>
<td>21.82</td>
<td>24.50</td>
<td>23.16</td>
</tr>
</tbody>
</table>

*aFrom Loomis and Sorg 1982.
bFrom USDA 1985 for the Chattahoochee and Oconee National Forests.

units of 1982 dollars per recreational visitor day (RVD). Values for national forests in the southern region, which extends from Virginia to Texas, ranged from a minimum of $10/RVD for picnicking to a maximum of $40 RVD for big-game hunting and upland hunting (Table 1).

The Forest Service then used the regional values to derive estimates for each national forest (e.g., USDA 1985 for Chattahoochee-Oconee National Forests in Georgia). To estimate the present value of each service, the demand for each service was projected 50 yr, multiplied by its value, then discounted to the present at a rate of 4%. For the Chattahoochee and Oconee National Forests in Georgia, value estimates ranged from a low of $5.21/RVD for developed recreation to a high of $31.31/RVD for small-game hunting (Table 1). These values can also be described per unit area (USDA 1985). On the basis of current management directions, present value benefits and costs are calculated for each activity, then costs are subtracted from benefits to determine net present value. By dividing net present value by the national forest area, values per hectare are obtained (Table 2). Recreation, wilderness, and water values total $2770 ha⁻¹ ($1121 acre⁻¹) in 1982 dollars for the Chattahoochee and Oconee National Forests.

Ziemer and Musser (1978) studied the demand for wildlife recreation in Georgia using a cost approach to estimate a consumer surplus value. Regression models were used to statistically estimate demand, using survey data from wildlife recreation participants. They report that the wildlife resources of Georgia are worth about $0.9 billion to the participants in those activities surveyed (Table 3).

Energy Analysis

The energy analysis methodology can be quite complicated (see for example, Costanza 1980, Costanza and Neill 1984, Costanza and Herendeen 1984). For this study we employed a simplified technique that is readily calculable (we discuss its shortcomings later). This technique uses the Gross Primary Production (GPP) of the whole ecosystem as an index of the energy captured by the system, and converts this energy value into dollars using a single dollar–energy conversion factor (described below).

The procedure can be summarized as follows:

1. Estimate the GPP of the natural area in question.
2. Convert the GPP estimate (usually measured in units of carbon fixed per time unit or the heat equivalent energy content of the carbon) to fossil fuel equivalents (FFE) by considering the fuel efficiency of each source.
3. Convert the FFE value into dollars using an economy-wide ratio of economic value per unit of energy, usually the ratio of GNP to total energy use in the economy (measured in FFE).

All three steps involve uncertainty. Below we discuss the steps in more detail, pointing out the potential sources of error.

Gross Primary Production. GPP is a measure of the solar energy that is used by the plants in the system to fix carbon into organic molecules, which then drives the rest of the ecosystem. The plants and animals in the system also moderate water flow, erosion, sedimentation, and other variables. GPP for an ecosystem can be considered analogous to GNP for an economy; both are crude (but essential) measures of overall system performance that do not consider the internal distribution of production and must therefore be used with caution. GPP measures the value of net inputs of energy going into ecological systems. GNP measures the total value of net outputs from economic systems (including capital accumulation and depletion) which is
Table 2. Valuations of nontimber and timber uses of the Chattahoochee and Oconee National Forests, Georgia.  

<table>
<thead>
<tr>
<th>Use</th>
<th>Present value benefits (range)(^b)</th>
<th>Present value costs</th>
<th>Net present value</th>
<th>Value per ha(^a)</th>
<th>1978 dollars</th>
<th>1982 dollars(^c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nontimber</td>
<td>(1978 million dollars (\cdot) yr(^{-1}))</td>
<td></td>
<td></td>
<td></td>
<td>2006.91</td>
<td>(2815.58</td>
</tr>
<tr>
<td>Dispersed recreation</td>
<td>631 - 622-651</td>
<td>10</td>
<td>641</td>
<td>-496.76</td>
<td>(217.98)</td>
<td>(1139.91)</td>
</tr>
<tr>
<td>Wilderness</td>
<td>51 - 53-59</td>
<td>1</td>
<td>50</td>
<td>219.63</td>
<td>(588.92)</td>
<td>(873.64)</td>
</tr>
<tr>
<td>Water</td>
<td>76 - 75-77</td>
<td>n/a</td>
<td>76</td>
<td>233.82</td>
<td>(135.15)</td>
<td>(135.15)</td>
</tr>
<tr>
<td>Developed recreation</td>
<td>35 - 19-41</td>
<td>125</td>
<td>-90</td>
<td>-290.62</td>
<td>(-149.69)</td>
<td>(-214.66)</td>
</tr>
<tr>
<td>and all others</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2186.17</td>
<td>2769.88</td>
</tr>
<tr>
<td>Total nontimber</td>
<td>813 - 779-823</td>
<td>136</td>
<td>677</td>
<td>2522.02</td>
<td>(873.64)</td>
<td>(873.64)</td>
</tr>
<tr>
<td>Timber</td>
<td>219 - 118-313</td>
<td>115</td>
<td>104</td>
<td>353.84</td>
<td>(184.95)</td>
<td>(184.95)</td>
</tr>
<tr>
<td>Total</td>
<td>1032 - 145-1131</td>
<td>251</td>
<td>781</td>
<td>3226.71</td>
<td>(1306.36)</td>
<td>(1306.36)</td>
</tr>
</tbody>
</table>

\(^a\)Data are from USDA (1985). Management Alternative 3. defined as the current direction.
\(^b\)Range includes minimum and maximum value across seven management alternatives.
\(^c\)Conversion: from 1978 to 1982 dollars uses ratio of 1982 GNP price deflator (1.0638) to 1978 GNP price deflator (1.032.09).
\(^d\)Values in parentheses are per acre.

Table 3. Outdoor recreation values for Georgia in 1971.  

<table>
<thead>
<tr>
<th>Activity</th>
<th>Value per occasion (1971 dollars)</th>
<th>Demand (1000/yr)</th>
<th>Total annual value 1971 dollars (1000/yr)</th>
<th>Total annual value per ha 1971 dollars</th>
<th>Total annual value per ha 1982 dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warm-water fishing</td>
<td>24.53</td>
<td>20,597</td>
<td>505,284</td>
<td>106.72</td>
<td>71.56</td>
</tr>
<tr>
<td>Small-game hunting</td>
<td>33.32</td>
<td>4,334</td>
<td>144,419</td>
<td>31.37</td>
<td>20.45</td>
</tr>
<tr>
<td>Big-game hunting</td>
<td>71.16</td>
<td>1,405</td>
<td>99,978</td>
<td>21.71</td>
<td>14.15</td>
</tr>
<tr>
<td>Wildlife enjoyment</td>
<td>6.24</td>
<td>2,603</td>
<td>162,451</td>
<td>35.27</td>
<td>22.99</td>
</tr>
<tr>
<td>Total</td>
<td>N/A</td>
<td>N/A</td>
<td>912,132</td>
<td>198.07</td>
<td>129.16</td>
</tr>
</tbody>
</table>

\(^a\)Data from: Ziener and Masuer (1978).
\(^b\)Values in parentheses are per acre.

equivalent for any given year to the total value of net inputs (labor, capital, government services, and natural resources) to the system.

Direct GPP measurements were not available for all the ecosystems of interest. However, we had estimates of Net Primary Production (NPP), which is analogous to the gross capital formation component of GNP. Estimates of NPP (Table 4) range from 0.5 mT ha\(^{-1}\) yr\(^{-1}\) for open water systems to 20 mT ha\(^{-1}\) yr\(^{-1}\) for wetland systems. The ratios used to convert NPP to GPP ranged from 1.42 to 3.34 times NPP, depending on the type of ecosystem and its successional position (E. O. Box, personal communication). Early successional ecosystems (like pine forest or cropland) allocate more GPP to NPP than do climax ecosystems (Odum 1969), just as rapidly growing...
### Table 4. Energy analysis estimates of nonmarket values by major land use in Georgia in 1982.

<table>
<thead>
<tr>
<th>Land use</th>
<th>NPP(a)(b) (mT/ha/yr)</th>
<th>GPP(a)(b) (mT/ha/yr)</th>
<th>Annual value(c) ($/ha/yr)</th>
<th>Present value(d) ($/ha)</th>
<th>1982 Area(b) (1000)</th>
<th>Total annual value(e) (million $/yr)</th>
<th>Total present value(f) (million $/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pine</td>
<td>9.39</td>
<td>17.40</td>
<td>232.00</td>
<td>5,795</td>
<td>4,687</td>
<td>1,075</td>
<td>26,865</td>
</tr>
<tr>
<td></td>
<td>(8.80)</td>
<td>(7.04)</td>
<td>(64.00)</td>
<td>(2,346)</td>
<td>(1,145)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hardwood</td>
<td>5.03</td>
<td>12.59</td>
<td>168.00</td>
<td>4,199</td>
<td>5,189</td>
<td>872</td>
<td>21,792</td>
</tr>
<tr>
<td></td>
<td>(4.04)</td>
<td>(5.10)</td>
<td>(68.00)</td>
<td>(1,700)</td>
<td>(1,281)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wetlands</td>
<td>20.00</td>
<td>66.02</td>
<td>889.00</td>
<td>22,203</td>
<td>260</td>
<td>231</td>
<td>5,781</td>
</tr>
<tr>
<td></td>
<td>(8.89)</td>
<td>(20.97)</td>
<td>(360.00)</td>
<td>(6,989)</td>
<td>(612)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open water</td>
<td>0.50</td>
<td>1.65</td>
<td>22.00</td>
<td>548</td>
<td>195</td>
<td>4</td>
<td>107</td>
</tr>
<tr>
<td></td>
<td>(0.20)</td>
<td>(0.67)</td>
<td>(9.00)</td>
<td>(222)</td>
<td>(183)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total natural areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>25,398</td>
<td>2,182</td>
</tr>
<tr>
<td>Crops</td>
<td>3.04</td>
<td>7.76</td>
<td>104.00</td>
<td>2,588</td>
<td>2,644</td>
<td>274</td>
<td>6,842</td>
</tr>
<tr>
<td></td>
<td>(2.20)</td>
<td>(5.14)</td>
<td>(42.00)</td>
<td>(1,048)</td>
<td>(553)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasture</td>
<td>3.80</td>
<td>7.76</td>
<td>104.00</td>
<td>2,588</td>
<td>889</td>
<td>92</td>
<td>2,299</td>
</tr>
<tr>
<td></td>
<td>(1.57)</td>
<td>(5.14)</td>
<td>(42.00)</td>
<td>(1,047)</td>
<td>(216)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total agricultural areas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5,727</td>
<td>366</td>
</tr>
<tr>
<td>Urban/other</td>
<td>3.50</td>
<td>7.01</td>
<td>94.00</td>
<td>2,399</td>
<td>861</td>
<td>81</td>
<td>2,014</td>
</tr>
<tr>
<td></td>
<td>(1.42)</td>
<td>(2.84)</td>
<td>(38.00)</td>
<td>(947)</td>
<td>(217)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>35,253</td>
<td>2,028</td>
</tr>
</tbody>
</table>

\(a\)From Turner (1985).

\(b\)Estimated based on conversions from NPP (from E.O. Box, personal communication).

\(c\)Based on conversion factors of \(4 \times 10^6\) Cal plant production/mton, 0.05 Cal fossil fuel energy/mton production, and 13,000 Cal fossil fuel energy/1982 dollar (from Costanza and Farber 1984).

\(d\)Based on a stream of constant production into the indefinite future and a discount rate of 1%. This makes the present value simply the annual value divided by 0.04.

\(e\)From Turner (1985).

\(f\)Annual values/ha - area, in millions of 1982 dollars.

\(g\)Present values/ha - area, in millions of 1982 dollars.

\(h\)Values in parentheses are on a per acre basis.

Economies put more of their GNP into new capital formation. The GPP estimates for each ecosystem type are listed in Table 4.

**Conversion to Fossil Fuel Equivalents.** GPP estimates are frequently stated in units of carbon or Calories of plant biomass per unit area per unit time. The first step in converting this to a measure of equivalent economic value is to convert it to energy units more directly relevant as input to the economy, i.e. fossil fuels. Fossil fuels are a much more concentrated, higher quality form of energy than plant biomass. Consider, for example, the extra energy required to upgrade biomass to fossil fuel, as in a biogas or gasahol process. Another example is to consider the relative number of Calories of biomass that would have to be burned in a power plant to produce the same amount of electricity as a given quantity of oil. Both of these methods have been used to estimate the "energy quality factor" of biomass relative to fossil fuel. An approximate average is 0.05 Cal biomass/Cal fossil fuel (Odum and Odum 1976), indicating that unprocessed biomass, such as that measured by GPP, is about 20 times less concentrated than fossil fuel. This value, however, is imprecise and would likely be improved by additional research.

**Conversion to Economic Value.** One can consider the overall ratio of the value of economic output to energy input in the economy as a crude way to convert plant production to an equivalent economic value. This step is certainly the most controversial, with critics arguing that energy consumption and economic value are not necessarily related (Huetner 1982). Although economic value and direct energy consumption are not, in fact, related, recent studies provide supportive evidence that total direct and indirect energy consumption (embodied energy) and dollar values are indeed highly correlated in the US economy (cf. Costanza 1980 and 1984, Costanza and Herendeen 1984, Cleveland and others 1984). We therefore use a conversion factor based on these studies to estimate the economic
value of ecosystem production from GPP estimates converted to FFE. This factor is approximately 15,000
Fossil Fuel quality Calories per 1982 dollar.

The nonmarket annual production value of each of the ecosystems based on GPP estimates and the
conversion factors discussed above are listed in Table 4. These values (in 1982 dollars) range from $22 to $360
ha\(^{-1}\cdot yr^{-1}\) ($9 to $147 acre\(^{-1}\cdot yr^{-1}\). This annual production value is then converted to a present value
(assuming a 4% discount rate) and extrapolated to the entire state based on the land area of each ecosystem
type.

Habitat Interdependence. The GPP technique outlined above does not account for interdependence
between habitats or differences in productivity within the same habitat. For example, all pine forest is assumed
to have the same GPP, regardless of the adjacent habitats or any special conditions of the site. In addition,
some ecosystems may be much more important for their roles in the landscape other than GPP. For
example, open water areas may be more valuable as water supply systems for animals or ecosystems than
for primary production, and the value of unique natural features, like the Grand Canyon, would be under-
estimated by GPP. To incorporate such factors would require a detailed and much more elaborate
version of energy analysis based on an ecologic-economic input-output flow accounting model (Costanza

Comparison of the CV and EA Estimates for Georgia Forests

A summary of nonmarket value estimates for Georgia forests is presented in Table 5. The EA estimate
(Table 4) and the CV estimate from Ziemer and Musser (Table 3) are very close. Both are approximately
$200 ha\(^{-1}\cdot yr^{-1}\) ($80 acre\(^{-1}\cdot yr^{-1}\) or $5000 ha\(^{-1}\) ($2000 acre\(^{-1}\) in 1982 dollars. The USDA estimate
(Table 2) is about half this.

Table 5. Summary of nonmarket value estimates for Georgia forests.

<table>
<thead>
<tr>
<th>Method (source)</th>
<th>Annual value ($1982/ha/yr)(^a)</th>
<th>Total value ($1982/ha)(^b)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>USDA (Table 2)</td>
<td>110.75</td>
<td>2769</td>
</tr>
<tr>
<td>Ziemer and Musser (Table 3)</td>
<td>144.84</td>
<td>(1121)</td>
</tr>
<tr>
<td>EA approach</td>
<td></td>
<td></td>
</tr>
<tr>
<td>This study</td>
<td>198.07</td>
<td>4952</td>
</tr>
<tr>
<td>(Table 4)</td>
<td>180.19</td>
<td>(2005)</td>
</tr>
</tbody>
</table>

\(^a\)Values in parentheses are per acre.

Total Value of Georgia

Market and nonmarket annual production estimates for the major land uses in Georgia are summarized
in Table 6. Our market estimates are based on gross sales per acre. Although this is not the actual
market sales price, it should be a good indicator of the gross sales prices of the land. Deriving a statewide
market price by observing transaction data would be ideal but difficult, and the gross sales approach is
more viable.

For agricultural and forest areas, nonmarket values are a significant portion of the total value (12% for
agriculture and 31% for forests). For wetlands, the majority of the total value is nonmarket, and it is
equivalent (on a per hectare basis) to agricultural market plus nonmarket value. For urban areas the
nonmarket component is insignificant (0.1% of the total). Thus, as land use changes from natural to
developed, value shifts from nonmarket to market.

The total annual value of marketed and nonmarketed production in Georgia was estimated as $74.4
billion (for 1982 in $1982). Total marketed production for 1982 was $71.8 billion and the nonmarket production
of natural and developed ecosystems was $2.6 billion (or 3.5%). The nonmarket value is comparable to
the annual marketed agricultural ($2.8 billion) and timber ($4.5 billion) production, both very important
industries in Georgia. Despite possible errors in the measurement techniques, the nonmarketed natural
production is an important component of the state’s economic well being.

Energy analysis estimates of nonmarket value are sensitive to the factor used to convert biomass calories
to fossil fuel calories. If a 0.10 Cal biomass/Cal fossil fuel value were used instead of the 0.05 Cal biomass
Cal fossil fuel value that we used, the nonmarket value estimates would double. The nonmarket component
of the state economy would thus increase to $5.2 billion yr\(^{-1}\). We used conservative values in our calculations,
and we believe our overall estimates are conservative.

Discussion

Energy analysis and contingent valuation are sophisticated attempts to unify ecology and economics.
Neither succeeds completely (Bernstein 1981; see also Gosselin and others 1974, Shabman and Batie 1978,
Odum 1978). One major impediment is that ecological and economic systems are perceived to operate on dif-
Table 6. Market and nonmarket annual production values of major land uses in Georgia.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Market production</th>
<th>Nonmarket value*</th>
<th>Total value</th>
<th>Areab (1000 ha)c</th>
<th>Total annual value (millions/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crops/pasture</td>
<td>783d</td>
<td>104</td>
<td>887</td>
<td>3,533</td>
<td>3,132</td>
</tr>
<tr>
<td></td>
<td>(317)</td>
<td>(42)</td>
<td>(336)</td>
<td>(8,727)</td>
<td>(31,196)</td>
</tr>
<tr>
<td>Forest</td>
<td>454e</td>
<td>200</td>
<td>654</td>
<td>9,827</td>
<td>6,432</td>
</tr>
<tr>
<td></td>
<td>(184)</td>
<td>(81)</td>
<td>(225)</td>
<td>(24,272)</td>
<td>(15,560)</td>
</tr>
<tr>
<td>Wetlands/open water</td>
<td>0f</td>
<td>889</td>
<td>889</td>
<td>459</td>
<td>405</td>
</tr>
<tr>
<td></td>
<td>(0)</td>
<td>(360)</td>
<td>(360)</td>
<td>(1,126)</td>
<td>(1,126)</td>
</tr>
<tr>
<td>Urban/other</td>
<td>74,700d</td>
<td>94</td>
<td>74,794</td>
<td>861</td>
<td>64,407</td>
</tr>
<tr>
<td></td>
<td>(30,243)</td>
<td>(38)</td>
<td>(30,281)</td>
<td>(2,127)</td>
<td>(2,127)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>14,677</td>
<td>74,377</td>
</tr>
</tbody>
</table>

*From Table 4, except forest which is from Table 5.

bFrom Table 4.

cValues in parentheses are on a per acre basis.

dFrom Ag Census data on Georgia total annual market value of farm products for 1982 ($2,782 million, excluding timber) divided by total crop and pasture area (8.727 million acres).

eFrom Table 2.

fAssumed to be negligible.

gFrom Akoska (1984) total 1982 nonagricultural gross state product ($64,329 million) divided by total urban other area (2,127,000 acres from Table 4).

Different time scales. The long-term detrimental effects of decisions that bring short-term economic gain are thus ignored (Bernstein 1981). As public education on the long-term of nature's services increases, our estimates of nonmarket values will probably also increase (Westman 1977).

Neither market nor nonmarket value estimates account for negative externalities of land use, such as pesticides associated with farming, or the habitat change and erosion associated with intensive forestry. These negative externalities, as well as the habitat interdependencies mentioned previously, must also be considered by decision makers. For natural ecosystems heavily impacted by human activities, replacement values can sometimes be useful (e.g., Gosselink and others 1974, Farnworth and others 1983).

Anticipated land use changes will have major impacts on the South's nonmarket values (Healy 1985). Plausible quality influences associated with land use changes include changes in game populations, harvest success, access to land for recreation, changes in the type and quality of wildlife supported on particular land uses, and aesthetic content (Musser and others 1982). Market and nonmarket values for conversion of forest land to agricultural uses in Georgia were studied by Musser and others (1982). They reported that between 1973 and 1976, such land conversions resulted in a loss of $13,700 acre−1 in hunting and fishing value, but a net gain of $82,580 acre−1 in overall value. An early study by Helliwell (1969) estimated the value of a 40-ha woodland in an agricultural region using values of four recognizable benefits of wildlife resources: production, potential production, education, and recreation. The estimated value of £52 was compared to an estimated value of only £31 if the woodland was cleared and planted in a spruce plantation. Thus, the value of the natural woodland was close to nine times the value of the plantation. Leaving land use decisions solely to the market would probably result in foreclosing important long-term options because of short-term gains (Healy 1985). Many of the linkages which could help establish the value of alternative resource policies are not well understood, and economists have too infrequently sought the assistance of biologists and physical scientists (Batie and Shabman 1979).

Imprecision and uncertainty remain in estimates of nonmarket values of natural systems. This uncertainty could be reduced by further research, but given the nature of the problem, it will probably remain relatively large. In natural systems management, a fundamental problem is that those who damage or destroy natural systems are not charged for the true social cost of that damage or destruction. Such situations in which the narrow, short-term incentives are inconsi-
tent with the long-term good of society are termed social traps (Costanza 1987). A trap can be transformed into a tradeoff by charging the responsible parties for the full cost of the environmental damage at the time the damage is done. Knowledge of the economic value of natural systems to society, along with costs of various activities, is necessary. An "environmental assurance bond" might be associated with the conversion of natural systems to other uses, in which the fees would be placed in a trust fund to mitigate environmental damage or to be proportionally returned in the case of minimal damage (Costanza 1987, Perrings 1987). This would effect a sharing of the societal costs among the parties that economically benefit from modifying natural systems, while also making ecologically sound development an attractive option in the short term.

Conclusion

There are many ways to discuss the value of nature (see for example, Van Dieren and Hummelink 1979, Rolston 1986). Some conservationists believe that non-attributable values (Farsworth and others 1981) are priceless and they object to any efforts to place monetary values on them. The Energy Analysis method provides a means for monetary valuation of at least the life-support good and services of an ecosystem. We believe this is useful because it demonstrates the magnitude and importance of these nonmarket values in units (dollars) that decision makers and the public can readily understand. Markets for ecological goods and services are far from perfect, and we cannot rely on the free market to efficiently allocate these resources. The current system, which misallocates these resources, is better described as a social trap. Implementation of a technique such as the environmental assurance bond may contribute to a truly ecologically sensitive economics. Changing land use patterns in Georgia and elsewhere will be accompanied by shifts in the relative importance of market and nonmarket values. The best estimates of nonmarket values may come from the application and interpretation of both approaches discussed in this article and the development of methods to deal equitably with the remaining uncertainty.

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