



Ecosystem Services in Forest Sector Models: A Review

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Introduction

- Forest biomass likely to play a significant role in future energy systems
 - Higher demand for forest biomass may lead to increased deforestation
- From a social perspective, it is important to consider the value of alternative uses for forests
 - Ecosystem services is one way to measure benefits provided by forests
 - For assessing different forest management regimes and forecasting policy effects, forest sector models are often used



Ecosystem Services

- Beneficial functions from an ecosystem
- Of direct or indirect value to people/society
- Ecosystem services can be abstract and difficult to value
- Early valuations of ecosystem services tend to aggregate the services over large areas



Ecosystem Services

- Supply of ecosystem services varies based on several factors such as:
 - Vegetation cover and type
 - Adjacency to rivers and bodies of water
 - Biodiversity hotspots
 - Proximity to population centers
- Because these factors can vary largely even within a single forest, a detailed spatial modeling (GIS) of ecosystem services leads to a better understanding of their value



Review

- Literature review of valuation studies for forest based ecosystem services in the last 20 years.
- Three key focuses
 - The most significant ecosystem services in forest ecosystems and their estimated value
 - The extent spatial modeling such a GIS mapping of ecosystem services is applied
 - To which extent ecosystem services has been integrated into forest sector models



Forest Ecosystem Services

- Provisional services
 - Timber, hunting, gathering of mushrooms & berries
- Regulatory services
 - Cycling of soil nutrients, Protection from flooding and erosion, Watershed protection
 - Carbon sequestration – of particular importance in relation to bioenergy
- Cultural services
 - Recreation, tourism



Forest Ecosystem Services

- Harvest value of forest land (in Sweden)
 - Average timber volume: 112 m³ / hectare (no bark)
 - Average price assuming 50/50 split between sawlogs and pulpwood: \$46.3 (390.5 kr)
 - Value of final harvest: \$5185 / ha
- The value of harvested timber can be compared to the yearly values of other ecosystem services when forests are preserved.



Carbon Sequestration

- Easier to quantify than other ecosystem services, almost always valued by applying an existing or hypothetical carbon tax
- Spatial dimension less relevant due to global effects of atmospheric CO₂
- Very different estimates between studies. \$10 - \$10000 / ha, with carbon price of \$25/tC.
- Average value is \$272 / ha
- Large differences in how carbon uptake of forests is modelled.



Carbon Sequestration

- The environmental and economic impacts of using forests as carbon sinks compared to using forest biomass for fuels has been analysed in many studies
 - No clear answers as to which method is best from an environmental perspective
 - Carbon sink strategy is more costly to the forest sector than a biofuel strategy
 - A mixed approach can lead to conflicting incentives between conserving forests and using forest biomass for fuels.



Hydrological Services

- Forests affect hydrological flows, offers flood protection, watershed protection...
- 24 studies were found that value the hydrological services of forests
- 75% of these were valued through replacement or avoided cost methods
- Flood protection is generally the highest valued hydrological service, average value of \$855 / ha
- In general, average value of hydrological services \$202 / ha



Hydrological Services

- Value of hydrological services particularly high for riparian forests and forests close to agricultural lands
- Forests can also provide important hydrological services for hydropower plants. Forest land provided waterflow changes valued at 43% of the equivalent value of timber in one study.



Other Regulatory Services

- Soil protection services valued in 14 studies
 - Replacement cost method and direct market pricing used for valuation.
 - Erosion prevention most highly valued service.
Average value of \$168 / hectare
- Air Quality Regulation valued in seven studies
 - High values in urban and peri-urban forests,
particularly for the absorption of small particles



Cultural Ecosystem Services

- The value of recreation in forests is estimated in 20 studies. Tourism is valued in eight studies.
 - Valuation is generally based on willingness to pay surveys such as contingent valuation where respondents to the survey state how much they are willing to pay for the ecosystem service.
 - Generally high values in developed countries. Average \$314 / ha
 - Low values in developing countries. Average \$11 / ha



Spatial Mapping of Ecosystem Services

- Increasing use of spatial mapping of ecosystem services, but majority of studies use aggregate values
 - Contributes to the highly different values found between the studies
- 19 studies were found that included GIS mapping of ecosystem services as well as estimations of their value
- Many were focused on ecosystem services that can be valued through market prices



Spatial Mapping of Ecosystem Services

- Studies that does include spatial mapping of ecosystem services may be more reliant on value transfer from previous studies due to the detailed modeling of terrain types
- However, value transfer is only meaningful from studies with comparable geography and climate, which necessitates detailed spatial modeling



Forest Sector Models

- Economic model for measuring the interactions between forestry and the forest industry
- Typically models the forest sector explicitly and treats other sectors of the economy as exogenous
- Commonly used for policy analysis and predicting the future markets for forest products
 - Has been applied for a variety of policy scenarios: trade barriers, forest conservation, climate change, etc...



Forest Sector Models: Review

- Generally simple assumptions regarding ecosystem services in forest sector models rather than explicit modeling
- Several applications of forest sector models where carbon sequestration is analysed however. Commonly in the context of biofuels.
- Other ecosystem services are only indirectly assessed in studies where the effects of increased forest conservation are measured.



Forest Sector Models: Review

- No examples of studies where the value of ecosystem services are integrated into broader scenario analysis or estimations of the social costs of increased deforestation
- The lack of forest sector models that include the value of ecosystem services may be related to a lack of data and difficulty in valuing many ecosystem services



Conclusions

- Harvest value of forest: \$5185 / ha
- Yearly value of ecosystem services
 - Carbon Sequestration \$272
 - Hydrological Services: \$202
 - Soil Protection: \$168
 - Recreation: \$314
 - Total Yearly value: \$956/ha (\$993/ha)
- Ecosystem services account for a significant part of the social value of forests



Conclusions

- Ecosystem services can help to optimally allocate the use of forest resources
 - Integration of ecosystem services into forest sector models would allow for more accurate estimates of the full societal costs of using forest biomass for fuels.
 - Spatial mapping of ecosystem services and biomass supply allows for more efficient cost benefit analysis of biofuel production and assessing of areas most valuable for preservation.
 - Development of spatial forest sector models where ecosystem values are included may be a beneficial direction of future research.