NATURAL RESOURCE ACCOUNTING: COUNTING THE FOREST AND THE TREES

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ABSTRACT

To obtain an accurate measure of the contribution of natural resources to welfare and sustainability, balance sheets containing values of depreciation and formation of natural resource capital, such as standing forests, must be developed. Theoretical models include both productive and amenity services, but current measures of forestry assets include predominantly productive values. Although depreciation of forest capital stocks due to production amounts to less than 0.2 percent of gross national product, this value does not represent the total contribution of forests to national welfare because the value of ecological services of standing forests are not included.

INTRODUCTION

Natural resource accounting measures the contribution of resource assets, such as standing forests, to national welfare (Peskin, Daly). The accounts are typically recorded in balance sheets showing the opening and closing stock values, and the depreciation, degradation and capital formation that occurred during the year. This accounting treats natural resource assets similarly to other types of assets or capital stocks (Xu et al.). Resource accounting provides information on the condition and change in individual resource assets. Perhaps more importantly, this accounting provides depreciation and degradation values which can be used to convert gross national product (GNP) into a measure more closely representing sustainable income or productivity (Solow). The idea is to ensure that use of an asset, such as a forest, will not be counted as improving current national welfare if this use is, in fact, impoverishing future generations. Thus gross national product, which is the sum of consumption and investment, is reduced by the amount of capital that is consumed in producing that level of consumption and investment. The revised measure is referred to as net national product (NNP), which has been shown, theoretically, to represent sustainable national welfare (Weitzman). Although gross

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domestic product is considered the appropriate measure for use in national analyses, in the U.S.
this number is rarely far from GNP, and thus the terms are frequently (and in this paper) used
interchangeably.

There are three common approaches to measuring natural resource assets—physical, cost-
based and value-based. Physical measures record changes in the physical stocks, but the links to
the economy and the usefulness in developing NNP are limited. Cost-based approaches, such as
the perpetual inventory method, are used to calculate the stock value of produced capital. The
stock value is equal to the sum of the appreciated value of previous investment costs. The flow
value in a cost-based approach is calculated as either a constant percentage of the stock value (the
"depreciation rate") or, in the case of pollution, as the cost of control. In value-based measures,
the stock value is the sum of the present discounted value of future benefits, while the flow value
is the willingness-to-pay for the commodity. For market goods, this is the price, while for
nonmarket goods, the willingness-to-pay would need to be estimated using an indirect approach
such as contingent valuation.

In forestry, the stock value is the value of the standing forest, capital formation is the value of
growth, and depreciation is the value of removals. Degradation occurs when the practice of
forestry damages the environment in some irreparable way, such as soil erosion or compaction.
Forests, forestry and forest products make positive contributions to measures of production which
are already included in the current NNP measure. However, the depreciation and formation of
forest stocks are not fully included in the accounts, and the value of forest amenities and
contribution of forests to clean air and water are not included at all. Forest resource accounting is
needed to provide a more complete record of sustainable forest use and the contribution of forests
and forestry to sustainable national welfare.

MODELS FOR NRA

The most common theoretical model for natural resource accounting is based on the solution
to an optimal control problem where the objective is to maximize intertemporal utility subject to
produced and natural capital constraints (Hartwick, Weitzman). In some of these models, stock
externalities are included, so that natural resource stock contributes to utility (Maler). In a
forestry model, the utility function would then be a function of both the income from harvesting
timber and the nonmarket benefits of a standing timber stock. The corrected measure of net
national product would then be calculated as conventional gross domestic product plus the value
of services of forest assets, less the depletion and degradation of these assets. Thus, NNP
provides a measure of sustainable utility, as long as you buy into the assumption that we know all
future utility functions, accept utility discounting as appropriate, and, that non-declining utility is a
reasonable societal objective.

The models proposed in the United Nations System of Economic and Environmental Accounts
(SEEA) are different from the theoretical model above, but are far more practical (Bartelmus et
al.). This system is based on Keynesian notions of production, consumption and investment, where NNP assumed to proxy for sustainable income. The model uses consumption as a measure of utility—as yet, utility from nonmarket goods and services is not included in consumption based measures unless there are market implications such as travel costs or land purchases. However, even these measures are not attributed to nonmarket services of natural resources in the accounts. In this system, NNP is calculated as conventional GNP plus the value of services of natural assets to production only, and the depletion of the productive value of natural assets due to consumption.

In the theoretical model, measures of three types of natural asset value are included: ecological-productive (clean air and water used in production), utilitarian-productive (actual outputs of timber and forage and minerals), and ecological-amenity (nonmarket services such as scenic beauty and birdwatching). The practical measures of these types of asset value, as proposed in the SEEA and adapted by the US Department of Commerce, Bureau of Economic Analysis (BEA) are discussed below. In addition, other proposals to measure some of the ecological values not included in the SEEA are discussed.

FORESTRY SECTOR ACCOUNTING

There are two specific forestry sector concerns, valuation of standing forests and valuation of pollution externalities from production. The valuation of standing forests involves measuring both the utilitarian-productive and the ecological-amenity values. Measuring changes in ecological-productive values includes the contribution of standing forests to clean air, clean water and future medicinal use as well as the depreciation of these elements due to mill effluent and harvesting. Currently, proposed modifications to accounts include measuring the utilitarian-productive values of standing forests and depreciation of stocks of air and water due to pollution. Ecological-amenity values from standing forests, whether positive (outputs) or negative (depreciation) are not included. Contribution of standing forests to the ecological-productive values of air and water are also not included.

Ecological-productive values.

Theoretically, pollution from production can be considered the use of clean air and water as a nonpriced input to production. However, because these values are difficult to quantify, the current methodology measures the loss resulting from pollution as equivalent to the cost of controlling the pollution. Because no attempt is made to measure the actual contribution of clean air and water to production, the SEEA balance sheet assumes these values stay constant. In addition, use of the cost of control assumes that we are fully able to control pollution to the precise optimal level. Both of these assumptions are grand, as well as improbable. An alternative method would be to use a value-based approach, which assumes the loss of benefits is equal to households willingness to pay to prevent pollution.

The BEA (US Department of Commerce) has prepared preliminary estimates of the balance sheet for air and water stocks, but these values are for all households and industries—sector
information is not yet available. The values for depreciation would be subtracted from GNP, assuming that the value of capital formation has already been included in GNP.

Utilitarian-productive values -- timber.

The SEEA also provides a framework for developing standing forest stock values and the components of changes to these values. The SEEA calculations assume that utilitarian-productive services of standing forests are included in the current accounts because timber is a priced output. As with most applications of economic theory, we are required to choose our fantasy -- cost-based measures assume perfect foresight happened in the past while value-based measures assume perfect foresight will happen in the future. A cost-based measure would accumulate the value of standing timber based on the appreciated value of timber investments, similar to the perpetual inventory model used in produced capital measurements. The currently used model is value-based, where the present discounted value of future harvests gives the value of the standing timber.

The BEA’s estimate of the value of all US standing forests includes only the utilitarian-productive stock and flow values of timber outputs. This estimate is part of the Integrated Economic and Environmental Satellite Accounts, which are designed as satellite or external accounts to be used in conjunction with the national income accounts. An estimate has also been made for Southern softwood standing timber value (Wear), although this is not discussed further in this paper. Measures of other types of values of standing forests are addressed in the next section.

The BEA estimates of standing forest value are shown in table 1. In this balance sheet, depreciation of the standing timber stock is harvest, capital formation is gross investment or growth on inventory. Net revaluation occurs because of a change in relative prices of timber and other goods. Primarily because of this revaluation, the closing stock for the end of 1987 is substantially higher than opening stocks. However, it also appears that the value of growth exceeds the value of harvest by 2.1 billion dollars.

Table 1. BEA Balance Sheet for Standing Forest Values, 1987.

<table>
<thead>
<tr>
<th>Trees on Timberland</th>
<th>Billion $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening Stock</td>
<td>288.8</td>
</tr>
<tr>
<td>Depreciation</td>
<td>-6.9</td>
</tr>
<tr>
<td>Capital Formation</td>
<td>+9.0</td>
</tr>
<tr>
<td>Net Revaluation</td>
<td>+44.9</td>
</tr>
<tr>
<td>Closing Stock</td>
<td>335.7</td>
</tr>
</tbody>
</table>
Using these totals and dividing by the total number of acres of timberland in 1987 results in net value per acre of approximately $600. This number is quite likely too high. From the Survey of Current Business, “The stumpage value estimates, based on the concept of net rent to the timber stand -- as distinct from the land the forest sits upon -- are derived mainly from private market data on payments for logging rights. As such, they should correspond to the present discounted value of the timber sales form the tract less the costs of logging, access, transportation and processing.” (P. 36). However, data they obtained from the USDA Forest Service was the are price per cubic foot less harvest and transport costs, not the present discounted value of the price which would prevail at time of harvest. Thus, current stumpage price was multiplied by the current growing stock inventory, even though this inventory would not all be harvested in the current year, resulting in a higher stock value than if the actual harvest hear were taken into account.

Other estimates of forest stock values.

Other value estimates include a composite of ecological values by a group called Redefining Progress (Cobb and Halstead) and estimates for forestland by the Federal Reserve. These last numbers are included in the BEA balance sheets, but are not consistent with BEA’s own estimates of standing forest value. The value of total forestland less the value of standing timber should reflect other forest values, some of which will be ecological-amenity and ecological-productive values. The BEA balance sheet also includes spaces for stock estimates of nonproduced environmental assets, specifically uncultivated biological resources such as wild fish, timber and other plants of uncultivated forests, other uncultivated biological resources.

The estimates of forestland in the BEA balance sheet were developed by the Federal Reserve (table 2). The opening stock of forestland is the total value of forestland, depreciation is the loss in soil fertility, which was assumed to be zero in 1987. Capital formation represents conversions into and out of forestland during the year, so there is an estimated loss of .6 billion dollars of land in forest uses in 1987. Again, net revaluation is the largest component of change. This estimate of forestland value divided by total acres of forestland (not timberland) results in a land value of approximately $400 per acre. This value is close to actual land selling values and is in line with Wear’s estimates for southern pine timberland.

Table 2. BEA Balance Sheet for Forestland, 1987 (Federal Reserve Estimates).

<table>
<thead>
<tr>
<th>Forestland</th>
<th>Billion $</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening Stock</td>
<td>285.8</td>
</tr>
<tr>
<td>Depreciation</td>
<td>-(n.a.)</td>
</tr>
<tr>
<td>Capital Formation</td>
<td>-.6</td>
</tr>
<tr>
<td>Net Revaluation</td>
<td>+29.4</td>
</tr>
<tr>
<td>Closing Stock</td>
<td>314.6</td>
</tr>
</tbody>
</table>
The Redefining Progress estimates of depreciation and degradation in standing forest value include only ecological values, but the distinction between losses to productive and amenity values are not made. The value of the loss of forests is proxied by the loss of old growth Pacific Northwest forests and externalities from road building on all National Forests. The total loss in 1987 is 49.2 billion dollars. This value of depreciation and degradation would be subtracted from GNP to get a correct NNP measure.

REVISED NATIONAL ACCOUNTS

The modified accounts proposed in SEEA and implemented by BEA would reduce NNP by .2 percent (table 3). The current GNP and capital consumption measures are from the Economic Report of the President (Council of Economic Advisors). Using the Redefining Progress estimates, the reductions from depreciation of the ecological-amenity and -productive values of forests amount to .8 percent of gross domestic product. Redefining Progress also makes other adjustments to GNP which are not included in the table. As this table demonstrates, the value of forest contributions to ecological-productivity (clean air and water) and ecological-amenities (scenic beauty and wildlife) are not added to conventional GNP. Thus, these NNP estimates underestimate the contribution of forests and forestry to national welfare.


<table>
<thead>
<tr>
<th></th>
<th>Current</th>
<th>BEA Revised</th>
<th>RP Revised</th>
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</thead>
<tbody>
<tr>
<td>GNP</td>
<td>4544.5</td>
<td>4544.5</td>
<td>4544.5</td>
</tr>
<tr>
<td>Less capital</td>
<td>-502.2</td>
<td>-502.2</td>
<td>-502.2</td>
</tr>
<tr>
<td>consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of standing forests</td>
<td>-6.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less consumption</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of forestland</td>
<td>-.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less consumption</td>
<td></td>
<td>-48.2</td>
<td></td>
</tr>
<tr>
<td>of ecological values</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NNP</td>
<td>4042.3</td>
<td>4034.8</td>
<td>3994.1</td>
</tr>
<tr>
<td>Percent difference</td>
<td>-.2%</td>
<td>-1.2%</td>
<td></td>
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</tbody>
</table>
Further information on the ecological-amenity values will be provided in my continuing research where I plan to use hedonic estimation to calculate a portion of these standing forest values. The calculated amenity values will be less than actual forest amenity values because information on the selling price of land is not available, but must be deduced from landowner harvesting behavior. Refinements of the utilitarian-productive values of timber in standing forests will also be made by predicting actual harvest age rather than assuming all timber is harvested at the optimal Faustmann rotation age.

LITERATURE CITED


