

Chapter 6

Conclusion

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This concluding chapter recommends a standardized approach to accounting for forest ecosystem services in the Southern States. First, we synthesize 10 principles from the preceding chapters. Next, we present a template for State forest ecosystem service assessments, recommending a staged approach with five outputs.

PRINCIPLES OF ECONOMIC ACCOUNTING FOR ECOSYSTEM SERVICES

1. **Accounting involves multiplying *total* quantities by *marginal* values.** Accounting requires understanding total annual flows of ecosystem services from forests; for example, the total volume of water that flows through a forest ecosystem, the sediment load in water exiting those ecosystems, or the net amount of carbon sequestered or released. Other examples include the total number of recreation user days or total volume of medicinal plants harvested. Weighting each of these physical flows by its marginal value provides an economically meaningful measure of the value of forest ecosystem services.
2. **Not all units of an ecosystem service have the same marginal value.** Just like a market price, the marginal value of an ecosystem service reflects its supply and demand in a particular time and place. Thus, the most useful measures of the value of ecosystem services are based on spatially disaggregated estimates of changes in the annual flows of those services multiplied by marginal values that reflect the level of supply (e.g., extent of forest ecosystem) and demand (e.g., number of people who can “consume” the ecosystem service) in different locations.
3. **Marginal values depend crucially on context.** Economic value reflects scarcity. When the supply of a good or service is limited, it is economically valuable. Goods and services with abundant supply are less valuable. Scarcity is relative, as it is determined by the relationship between the supply and the demand for a good or service at a particular time and place. Thus, values calculated for one time and place may be very different for another. A spatial catalog of values can serve for both tracking changes over time and for cost-benefit analysis of alternative policies.
4. **When ecosystem services are public goods, their value depends on the size of the “public.”** Demand—or willingness to pay—is, in general, greater the larger and the wealthier the affected population. Thus, in addition to quantifying the flows of ecosystem services in particular times and places, the analyst must consider the size of the population that benefits from those services. The relevant “public” can range from immediate downstream water users to the global population affected by climate change. State assessments should identify both the relevant “public” who reside in the State, and the total “public” of all people who benefit from ecosystem services generated by forests in the State no matter where they reside.
5. **Diminishing returns are critical and inescapable.** The other side of the valuation coin concerns the abundance of supply. Economic value is determined on the margin: the economic value afforded by an acre of forest is determined not by the services the forest as a whole provides, but rather, by what *additional* services that acre provides over and above those that would have been available in its absence (i.e., the forest’s marginal product). With rare exceptions (e.g., where additional acres provide habitat contiguity), the value of the ecosystem services provided by each additional unit of forest diminishes as the total area of forest increases, and vice-versa: i.e., an additional unit of forest is more valuable where there is less total forest area. Analysts should only use valuation methods that acknowledge diminishing returns, and they should caution against inappropriate use of their estimated marginal values. For example, they should discourage multiplying the total acres of forest in a State by the marginal value of ecosystem services from one additional acre of forest.
6. **Only *final* services should be included to avoid double-counting.** It is inappropriate to sum the value of an ecosystem service that contributes to some final outcome and the value of that outcome itself. For example, we do not need to estimate the value of the soil structure created by forests if we have an estimate of the value of the resulting stabilization of water flows, because the value of the soil structure as an input into the hydrological system is already reflected in the value of that watershed service. Likewise, accounts should not include both the value of a forest in filtering water so that expensive purification is not required and the cost savings from not having to purify water that has been cleansed by a forest. A corollary is that in order to fully account for forest values, we need estimates of the values of all final ecosystem services now and into the future.

7. **Some—but not all—final ecosystem services are reflected in traditional economic accounts.** The value of the inputs used to produce marketed goods and services is reflected in the value of those goods and services as recorded in GDP (Gross Domestic Product). Because inputs include forest ecosystem services, we can say that some part of GDP is attributable to those services. For example, the total value of agricultural production reflects the values of hydrological and pollination services provided by forests to the agricultural sector. In this case, accounting for forest ecosystem services means giving them credit for their contribution to GDP. Other ecosystem services affect well-being directly in ways that are not counted in GDP, e.g., by providing a more pleasant environment and creating a sense of place. Just as the value of home-cooked meals (and therefore the contribution of home cooks to our well-being) is excluded from GDP, so are the psychological benefits of the forest landscape (and therefore the contribution of that cultural ecosystem service from forests).
8. **Economic accounts sum up changes experienced by everyone in the accounting framework, e.g., everyone in the State.** A positive sum indicates the possibility that everyone could gain. For example, an increase in the total value of forest ecosystem services in a State means that there is a positive gain in value that *could* be distributed among everyone in the State. However, gains (and losses) are almost never distributed evenly, and concentrated gains or losses are often the most visible and most discussed. Both accounting totals and the distribution of gains and losses are relevant to forest policy decisions.
9. **Accounting for ecosystem services necessitates thinking broadly ...** Ecosystems give rise to economic values that span a broad spectrum. At one end are those that accrue largely to private individuals in consequence of private choices, such as recreational use of forests or collection of non-timber forest products. At the other end are values that may benefit people around the world, such as carbon sequestration. Some global values, for example the value of preserving endangered species, may not be associated with any market transactions. In between are services provided to local communities, such as flood protection and groundwater re-charge. Information from multiple sources is required to estimate quantities and values for the various types of services. Even in State studies focusing on values that accrue to State residents, values to populations outside the State should be noted, as they are likely to be relevant to the design of ecosystem service markets and national policies that affect the State.
10. **... but also prioritizing.** The ultimate goal of ecosystem accounting exercises is to express all ecosystem service values in dollar terms. This is a long-term aspiration that is not fully achievable in the near future. Meanwhile, State assessments can:
 - a) identify all relevant forest ecosystem services (and disservices),
 - b) note those likely to be most affected by changes in forest area,
 - c) compile estimates of the marginal value of those services from comparable prior studies, and
 - d) call for additional research on services that lack marginal values but that are likely to be both valuable and vulnerable to changes in forest ecosystems.

In this way, State assessments can focus future valuation efforts on ecosystem services with values that are likely to be substantial but that have not been estimated using theoretically and methodologically sound approaches. They should steer researchers away from “deriving more precise estimates of zero,” i.e., employing the best methods and data to estimate values that are too small to affect decisions about forests. While this future research is pending, State assessments should focus on quantifying annual flows of these ecosystem services in physical terms, rather than heroically extrapolating values from other studies in ways that ultimately cannot be defended. An adage worth remembering here is that “absence of evidence is not evidence of absence.” The forest ecosystem services that have been valued in monetary terms are just a subset of all ecosystem services relevant to decisions about forest policy and management.

RECOMMENDED STRUCTURE FOR ASSESSMENT OF FOREST ECOSYSTEM SERVICES

These 10 principles imply that economic accounting of ecosystem services is not a single well-defined task, but rather requires tapping numerous data sources, making numerous judgment calls, and tailoring the approach to numerous different ecosystem services. As a result, we recommend that States undertake ecosystem services assessments in stages (fig. 6.1), allowing for adaptive management of the process and generating several kinds of outputs.

State assessments of forest ecosystem services should, at a minimum, generate the following five outputs:

1. **A statement** listing the ecosystem services generated by forests in the State,
 - a) highlighting priorities for future valuation studies (ecosystem services that are expected to be important but that have not been valued),
 - b) identifying services that can be included in accounts by transferring values from prior literature, and
 - c) acknowledging other forest ecosystem services with currently unknown values.

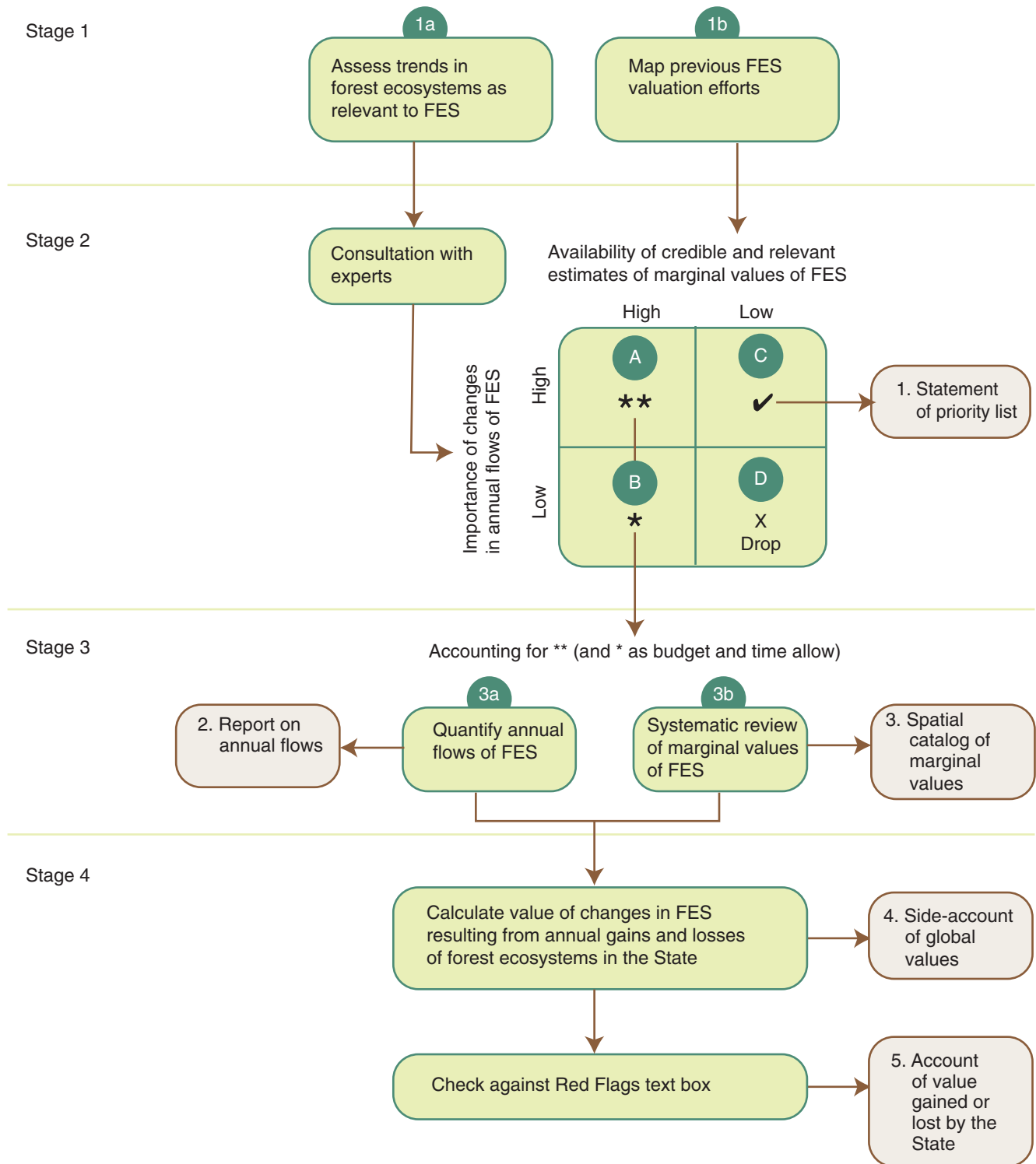


Figure 6.1—Template for Forest Ecosystem Service Assessment.

2. **A report** on the annual flows of tangible forest ecosystem services per acre and in total from each forest type in each spatial zone in the State.
3. **A spatial catalog** of the marginal values of forest ecosystem services, per unit of final ecosystem service or per unit of forest, for each forest type in each spatial zone.
4. **A side account** of national and global values (to people residing outside the State) for ecosystem services gained or lost due to changes in forest ecosystems in the State from year to year.
5. **An account** of the value to State residents of ecosystem services gained or lost due to changes in forest ecosystems in the State from year to year.

The first output, produced from scoping studies and consultations in the early stages of the assessment, should provide a complete list of ecosystem services generated by forests in the State classified on 1) the likely importance of changes in the service due to loss or gain of forest ecosystems and 2) the availability of credible and relevant estimates of the marginal value of the service.

Services of high importance but lacking prior estimates should be included in a priority list for future research to inform State funding decisions and encourage other funders and researchers to focus valuation efforts on priority forest ecosystem services. Ecosystem services that have high importance and high availability of prior estimates should be evaluated in the remaining stages of the assessment, using benefit transfer to develop accounts and analyze policy alternatives. Depending on budget, time, and State priorities, ecosystem services with relatively low importance but high availability of prior estimates could also be included in the remaining stages of the assessment.

The second and third outputs should be developed in tandem, using consistent definitions and measurements of final ecosystem services to quantify their marginal production by forests and their marginal value to State residents. For ecosystem services that are not tangible and not associated with any observable behavior (such as many cultural services), the most appropriate measure may be area of the forest ecosystem. However, in most cases, the area of forest ecosystem should be considered as an input to production of a final ecosystem service.

Specifically, the second output should quantify annual flows of final forest ecosystem services in physical units appropriate to each service, generating both spatially differentiated estimates of the marginal product of forests, and “headline” numbers such as the proportion of a State’s drinking water that flows through forest ecosystems. The third output compiles estimates of the marginal value of those same final forest ecosystem services from previous studies. The resulting spatial catalog of marginal values is the key tool for developing accounts of the economic

gains and losses due to changes in forest area over time and due to policy alternatives.

Finally, the fourth and fifth outputs are the typical outputs of green accounting exercises, depending on the accounting framework adopted. These accounts serve the purpose of monitoring, managing, and reporting the change in value of ecosystem services due to annual gains or losses in forest ecosystems in the State. The focus of State assessments is typically on the value of forest ecosystems to residents of the State. However, some ecosystem services from State forests also benefit people outside the State, at scales ranging from the population residing in watersheds fed by a State’s forest to the global population that benefits from mitigation of climate change through carbon sequestration in the State’s forests. We recommend tracking these values in a side account, recognizing that they can be only partially captured by State residents through ecosystem service markets or national policy.

To generate these outputs, assessments should proceed through the four stages illustrated in figure 6.1: 1) scoping studies, 2) consultation to set parameters, 3) in-depth studies, and finally 4) economic accounting of the value associated with changes in forest ecosystems in the State.

Stage 1

The first stage comprises two scoping studies to inform decisions about which ecosystem services to consider in the five outputs. Based on meetings with stakeholders from the Southern States, we recommend that at minimum, all assessments should include the following three categories of services:

- a) watershed services (regulation of flow and maintenance of quality),
- b) recreation (including tourism and hunting), and
- c) supply of forest products with the greatest market values.

Because the market value of timber is already well understood and incorporated into policy decisions in the Southern States, the added value of an ecosystem service assessment is to account for non-timber values generated by forests, including non-timber products and services. The three categories listed above have been identified as the most important regulating, cultural, and provisioning services of southern forests and should be included in any assessment.

Of course, these are just a subset of all forest ecosystem services, and the scoping studies are intended to identify other services that should be included in particular State assessments, such as other cultural services and regulation of air quality and climate. Specifically, scoping study (1a) identifies important changes in forest ecosystem services by quantifying changes in the area

of forest ecosystems over the past decade (or other recent time period), and scoping study (1b) surveys the literature on the economic value of ecosystem services, generating a “systematic map” of forest ecosystem service valuation.

For scoping study (1a), we recommend first identifying forest zones that 1) have the biggest effect on watershed functioning (see Chapter 3) and 2) are likely to support the most recreation, including hunting (see Chapter 2). Second, we recommend quantifying change in forest area over the past decade in the State as a whole and in those high value zones (for water and for recreation). Note that these zones are likely to overlap (see fig. 6.2). Change in forest area could be quantified as conversion into or out of FIA forest types (planted pine, natural pine, oak-pine, upland hardwood, lowland hardwood). Based on these changes in forest area in the State as a whole and in the high value zones, the analyst can identify forest ecosystem services likely to have undergone important change.

For scoping study (1b), we recommend a “systematic mapping” approach (Atmadja and Sills 2015, Haddaway and others 2016, James and others 2016, McKinnon and others 2015), supplemented by careful review of on-line catalogs, databases, and models designed to support benefits transfer (ESVD 2017, EVRI 2017, InVEST 2017, Loomis and others 2008, RUVD 2017, USGS 2017). The objective is to assess the availability of credible and relevant estimates of the marginal value of forest ecosystem services. Credibility should be assessed based on the criteria described in the relevant chapters of this guide, as well as

the general principles above and red flags (text box, next page) (e.g., the estimates should reflect benefits rather than costs, and the estimation methods should account for diminishing returns). Relevance should be based on the qualitative similarity of the study site to the State in terms of the type of forest, the relative scarcity or abundance of forest, and the size and income level of the population that benefits from the ecosystem service. The analyst can then determine whether there is relatively high or relatively low availability of credible and relevant estimates of the marginal value of each forest ecosystem service. This scoping study should also take note of the definition and measurement of the final ecosystem services that are valued, as an input to stage 3.

Stage 2

Both the managing agency and the research team should be involved in this stage, drawing on the results of the scoping studies and consulting with experts, in order to define the parameters for the rest of the assessment. In particular, the managing agency and other State forest experts should help verify and supplement the list of forest ecosystem services undergoing important changes in value. Specifically, they can offer insights about how future trends may diverge from past trends in forest ecosystems (e.g., due to socio-demographic and economic factors, policies and programs, or natural disasters and climate change) and other factors that shape the importance of ecosystem services (such as the cultural traditions and economic activities in the State).

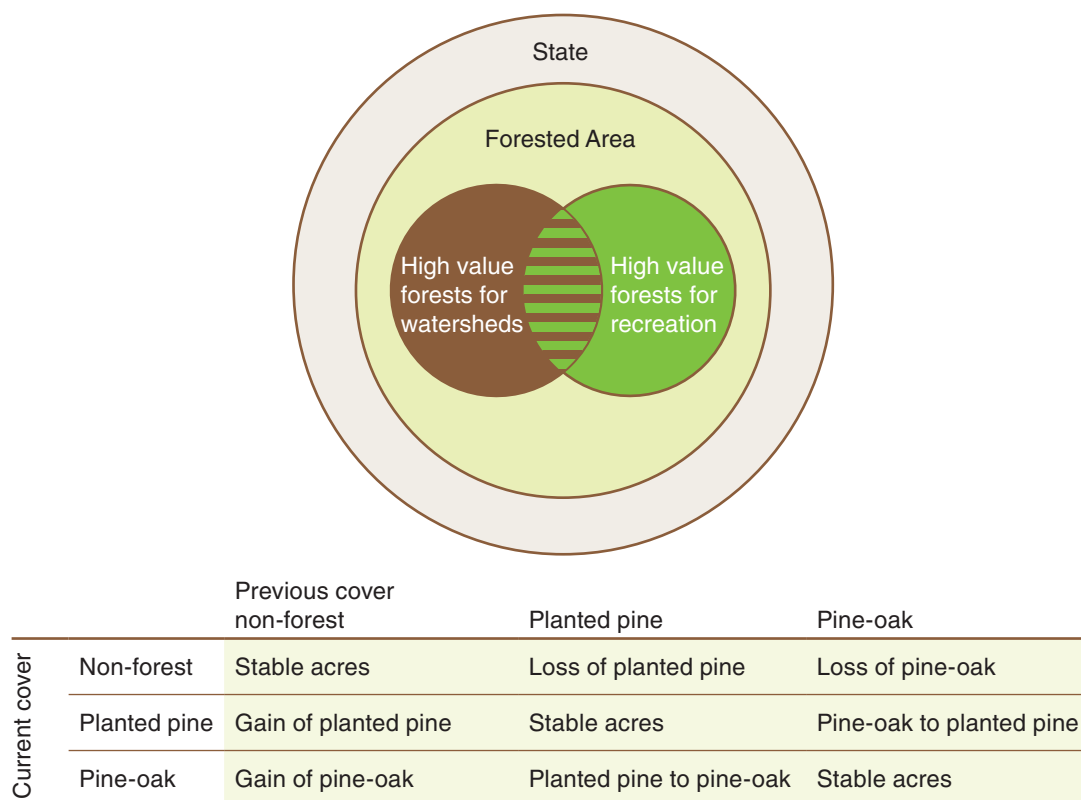


Figure 6.2—Scoping for important changes in forest ecosystem services: forest transitions in priority areas.

RED FLAGS

**Assuming forest is managed to optimize each ecosystem service.**

To estimate the annual flows of all ecosystem services that can be produced simultaneously by an acre of forest, it is important to make consistent assumptions about how that forest is managed. Management to optimize production of one ecosystem service will not necessarily optimize production of other services.

**Assuming a single fixed value for the marginal product or for the marginal value of an ecosystem service across all forest types and all locations.**

This is unlikely to be valid, because the relationship between the area of a forest ecosystem and the flow of forest ecosystem services is often non-linear, and marginal values are typically higher where ecosystem services are scarcer and where more people benefit. The principle of diminishing returns (i.e., diminishing marginal productivity and diminishing marginal utility) suggests that marginal values should generally be less than average values.

**Transferring marginal values from study sites with different forest types, different levels of abundance or scarcity of forest, and/or different income levels of the affected population.**

The study and target site should be similar for unit value transfers and should have an overlapping range of characteristics for predicting values based on benefit functions.

**Summing the values of intermediate and final services.**

This would almost certainly mean that some values have been double-counted because the value of final services includes the value of inputs (e.g., the values of regulating and provisioning), while cultural services include the value of supporting services (e.g., biodiversity and nutrient cycling).

**Summing the values of overlapping sets of services estimated by different methods.**

This results in double-counting services that appear in more than one set. In particular, stated preference surveys often encompass several services, some of which have also been the subjects of revealed preference studies.

**Combining estimates of values to different populations.**

State accounts should include values to State residents, with values to other people reported separately. For example, the social cost of carbon is an estimate of the global cost of climate change due to carbon emissions, and therefore should not be reported in the same account as air quality benefits to State residents. In this case, the market value of carbon offsets may be a better estimate of the value to State residents.

**Estimating ecosystem service values larger than relevant total values.**

For example, the value of avoided damage to a sector should not be larger than the total value added of that sector, and willingness to pay should be bounded by income.

**Combining measures of economic impacts or multiplier effects from regional economic analysis with estimates of economic values.**

These are based on fundamentally different assumptions and should not be added together, although they may provide useful complementary perspectives.

**Employing estimates of cost instead of estimates of value.**

In general, replacement or restoration costs are not valid estimates of value. Likewise, expenditures on recreation—including travel costs—measure costs, rather than value.

**Reporting single values with no indication of uncertainty.**

Accounts should not rely solely on point estimates, but rather should draw on confidence intervals where available and conduct bounding exercises (using minimum and maximum possible values) when confidence intervals are not available. Likewise, analysts should assess sensitivity to key assumptions, such as the size of the beneficiary population and the discount rate for calculating present value.

The next step is to plot the ecosystem services based on 1) their expected importance and 2) the availability of credible and reliable estimates of marginal value. They can then be sorted into the four categories shown in figure 6.1:

- A. Ecosystem services that are undergoing significant changes (e.g., due to changes in forest ecosystems) and that have credible and relevant estimates of marginal value: these should be the primary focus of accounting efforts, since they are both important and possible to value.
- B. Ecosystem services with fairly stable flows and with credible and relevant estimates of marginal value: these ecosystem services should be included in accounting efforts only if there is sufficient time and budget allocated to those efforts, because they are lower priority than the services in category A.
- C. Ecosystem services that have been significantly affected by changes in forest ecosystems but with no credible/relevant estimates of marginal value: these ecosystem services should be excluded from accounting exercises—thus avoiding the temptation to guesstimate or extrapolate to obtain marginal values. Instead, they should be added to a priority list of ecosystem services for future valuation studies. Depending on the budget, these studies may be part of the ecosystem service assessment. However, even if sufficient funding is not available, a formal list of State priorities, supported by a clear statement of the policy needs and information gaps (output 1), could influence and help researchers obtain funding for future research on these priority services.
- D. Ecosystem services with fairly stable flows and no credible and relevant estimates of marginal value: given likely low importance and lack of information, these ecosystem services should be acknowledged but not quantified in ecosystem service assessments.

To ensure that accounts provide a conservative or lower-bound estimate of the total value of forests, any significant disservices of forests such as water use by fast growing plantations, wildlife damage/hazards, or production of volatile organic compounds (VOCs) should also be acknowledged (cf., Escobedo and others 2011). If values of the (dis)services have been quantified in prior studies, they should be included in the accounts. Otherwise, they are candidates for the priority list for future valuation studies (category C).

In addition to defining which ecosystem services to include, this stage should also define how to disaggregate the State into spatial units for purposes of calculating changes in the annual flows of ecosystem services and their marginal values. At one extreme, each acre of forest might offer different marginal products and values of ecosystem services. At the other extreme, some previous State assessments have used a single average value

for all forests in their State. We recommend an intermediate solution, using FIA forest types (planted pine, natural pine, oak-pine, upland hardwood, lowland hardwood) as the highest level of disaggregation. Forest types should then be disaggregated as appropriate for each ecosystem service. These may overlap, as shown in figure 6.2 for watershed and recreation services. However, as long as they all nest in FIA forest types, they can be summed and aggregated.

Stage 3

This stage includes two studies that build on the scoping studies in stage 1 but focus on the smaller set of ecosystem services defined in stage 2.

Study (3a) quantifies total annual flows of ecosystem services from forests in each spatial unit defined in stage 2. Study (3b) generates a database of marginal values (and functions to compute marginal values) of each ecosystem service in each spatial unit defined in stage 2. These studies must be coordinated, so that the definitions and units of the final ecosystem service outputs quantified in study (3a) are the same as the final ecosystem services that are valued as inputs to production and well-being in study (3b). For some ecosystem services, marginal values may be reported for the service generated by an acre of forest, without specifying the quantity of service generated by that acre. This is particularly likely for non-tangible ecosystem services, such as a sense of place and natural heritage.

For most ecosystem services, study (3a) should quantify:

- a) the marginal product of an additional acre of forest (i.e., how many more units of each final ecosystem service are generated by an additional acre of forest),
- b) the extent of the market or the population that benefits from each service, and
- c) the total annual flow of each ecosystem service, in each of the spatial units defined in stage 2.

The marginal products and population of beneficiaries are used for accounting in stage 4. The total annual flows form the basis for a report on the magnitude of forest ecosystem services (output 2), including “headline numbers” such as the percent of drinking water that flows through forests, total air pollutants removed by forests, and number of recreational use-days in the State’s forests.

Study (3b) is a systematic review of marginal values of final forest ecosystem services reported in the scientific literature. Systematic reviews follow replicable procedures for searching the scientific literature and extracting consistent information from each study (Atmadja and Sills 2015, Moher and others 2009). In this case, the search protocol should screen for studies that

estimated marginal values of ecosystem services in similar forest biomes and socio-economic settings (i.e., temperate forest in developed countries). The information extracted should include:

- a) the marginal value or the function that describes that value, specifying the units and year in which estimated,
- b) which ecosystem services are included in the value,
- c) whether the estimated value is for an annual flow of services or the capitalized value of all future services that a forest will provide,
- d) the size of the population that benefits from services that are public goods,
- e) characteristics of the beneficiary population in the study site (spatial extent, education, income level), and
- f) characteristics of the forest in the study site, including forest type, extent, and how managed.

In addition, the reviewer should assess the credibility of the estimated values. This includes verifying that the study in fact estimated benefits (willingness to pay, change in welfare or utility) rather than expenditures or economic multipliers, and that it used a generally accepted method of valuation (as described in the previous chapters). It is also worth noting whether the estimated values have been assessed for plausibility (e.g., by comparing estimated total benefits with total income or total output).

Stage 4

The outputs of stage 3 can be used in a variety of ways to help monitor and manage change in forest ecosystems. This includes cost-benefit analysis of forest policy alternatives, selecting critical forest zones to target policy interventions, and identifying the best response to externally set standards (e.g., Federal standards for water quality). The first step is to quantify the extent of forest gain or loss in each spatial unit under each alternative considered (including the status quo). Both the type of forest and its management should be specified. Second, use the estimated marginal product of each final ecosystem service generated by a particular forest type under a particular management regime to quantify the changes in ecosystem

services. Finally, apply the marginal values appropriate to each final ecosystem service in each spatial zone to generate the economic value.

The primary objective of this accounting is to quantify the value to State residents of changes in the State's forest ecosystems. However, the literature also contains estimates of the marginal value of forests to the national or global population; for example, the social cost of carbon is an estimate of the total global cost of additional climate change due to one additional tonne of carbon dioxide emitted. These global values may be relevant to State residents if they are altruistic and care about the benefits that their State forests provide to the world, or if they expect to benefit from sales of those services in ecosystem service market. Thus, we recommend recording these national or global values in a side account (output 4), keeping them separate from the main account but ensuring that they are available for future negotiations.

There are many potential pitfalls when combining data and parameters from different sources in order to estimate values (see text box, p. 100). First, the marginal product and the marginal value must refer to the same final ecosystem service, defined in the same way, using consistent units. Second, some marginal values will have been estimated for bundles of ecosystem services, and in other cases for individual services. To obtain a defensible, lower-bound estimate, it is critical to avoid any double-counting. Last, we emphasize that the marginal values extracted from the literature are appropriate for valuing changes (not totals) in similar forest types and similar socio-economic settings as the study site.

As long as these red flags are heeded and pitfalls avoided, the report on changes in quantities of forest ecosystem services and the spatial catalog of marginal values of those services can be used to create an ecosystem services account that reports the value lost or gained by State citizens due to annual losses or gains of different forest types in different spatial zones (output 5). This account should be constructed from estimates of change in each spatial zone. We do not recommend reporting a "total value" of ecosystem services by summing the products of total forest area, marginal product, marginal values for each zone and for each service, because that would surely underestimate the total value of all forests, given the principle of diminishing returns.

Finally, we note that both outputs 4 and 5 report ecosystem service values both that contribute to GDP as conventionally measured (e.g., increased productivity of fisheries) and that represent additions to GDP (e.g., contribution of trout fishing to quality of life). These are worth distinguishing to facilitate interpretation and use of the accounts to understand the contribution of forests to the economy and to well-being.

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