Ecosystem benefit indicators

Excerpt from draft SAB Committee report, *Valuing the Protection of Ecological Systems and Services:* *Ecosystem benefit indicators offer quantitative metrics that are generally correlated with ecological contributions to human well-being and hence can serve as indicators for these contributions in a specific setting. They use geo-spatial data to provide information related to the demand for, supply (or scarcity) of, and complements to particular ecosystem services across a given landscape, based on social and biophysical features that influence – positively or negatively – the contributions of ecosystem services to human well-being. Examples of these indicators include the percentage of a watershed in a particular land use or of a particular land type, the number of users of a service (e.g., water or recreation) within a given area, and the distance to the nearest vulnerable human community.*

Ecological benefit indicators can serve as important quantitative inputs to valuation methods as diverse as citizen juries and economic valuation methods. Ecosystem benefit indicators provide a way to illustrate factors influencing ecological contributions to human welfare in a specific setting. The method can be applied to any ecosystem service where the spatial delivery of services is related to the social landscape in which the service is enjoyed. However, although the resulting indicators can be correlated with other value measures, such as economic values, they do not themselves provide measures of value.

Further reading

Boyd, J. 2004. What's nature worth? Using indicators to open the black box of ecological valuation. Resources. 50

Boyd, J., D. King, and L. Wainger. 2001. Compensation for lost ecosystem services: The need for benefit based transfer ratios and restoration criteria. Stanford Environmental Law Journal 20.

Boyd, J., and L. Wainger 2002. Landscape indicators of ecosystem service benefits. American Journal of Agricultural Economics 84.

Wainger, L., D. King, J. Salzman, and J. Boyd. 2001. Wetland value indicators for scoring mitigation trades. Stanford Environmental Law Journal 20.

Overview. *Valuing the Protection of Ecological Systems and Services* describes a range of valuation methods. The choice of method will depend on the environmental question at hand, the political and regulatory process involved, and differing philosophical perspectives on the nature of value and how it is to be determined by society. All of these methods, however, require the analyst or decision maker to be informed.

Two basic forms of information are required: the knowledge of what is at stake in nature and the ability to determine how ecological endpoints change as a result of management or regulation. The first piece of information comes under the realm of biophysical production function analysis. If EPA can achieve clear, actual or predicted production function-based outcomes, that would be a great advance over current practice.

Assuming these kinds of information and analysis are available, social scientists are then called upon to weight, prioritize, or value different outcomes in nature. What kind of information should be relied upon for weighting, priority-setting, and valuation of ecological changes?

Elsewhere in this report the committee has emphasized the importance of ecosystem *services'* spatial and landscape context. *Where* services arise is very important, both ecologically and socially. From a social science standpoint, the determinants of value depend upon the landscape context in which ecosystem services arise. Habitat support for recreational and commercial species, water purification, flood damage reduction, crop pollination, and aesthetic enjoyment are all enjoyed in a larger area surrounding the ecosystem in question. Ecosystem Benefit Indicators (EBIs) allow for spatial representations (both geo-coded data and corresponding visual depictions) of social and biophysical features that enhance or decrease the benefits of a particular ecosystem services in particular places.

Regulatory and ecological ecosystem assessments, including many of those reviewed by this committee, often ignore information that is fundamental to valuation – however valuation is defined. For example, how many people benefit from a particular ecological function or service? The number of people who can enjoy the service in a given location is an example of an important EBI.

- The committee also found scant evidence that the Agency analyzes the scarcity of particular ecosystem services, the presence of substitutes for those services, or the dependence of environmental benefits on the presence of complementary goods and services. EBIs are a way to relatively quickly and cheaply address this information gap.

- EBIs are of practical use to the Agency because the cost of collecting them is relatively low. EBIs are generated from GIS data and can be quickly assembled, usually using existing data sets employed by federal, state, and local governments.
- EBIs can and should be used to educate decision makers and stakeholders about the underlying complexity of ecological and economic relationships. They are not a way to simplify the decision maker's problem. Rather, they provide basic information that informs the decision process about the trade-offs arising from a particular decision.

Examples

To illustrate the use and benefits of EBIs, consider the following example: wetlands can improve overall water quality by removing pollutants from ground and surface water. This ecological function is valuable, but just how valuable? To answer this question one can count a variety of things, such as the number of people who drink from wells attached to the same aquifer as the wetland. The more people who drink the water protected by the wetland, the greater its value.

But other things matter as well. For example, is the wetland the only one providing this service or are others contributing to the aquifer's quality? The more scarce the wetland, the more valuable it will tend to be. There may also be substitutes for wetland water-quality services provided by other land-cover types such as forests. Mapping and counting the presence of these other features can further refine an understanding of the benefits being provided by a particular wetland.

Many ecosystem benefits arise only in the presence of complementary features. Recreation typically requires access to natural areas. Road, trail, dock or other forms of access are thus important to the analysis of benefits. In some cases, if there is no access, there can be no benefit.

Consider another type of environmental benefit: aesthetic value arising from natural viewscapes. Here, relevant stakeholders and decision makers would benefit from the following kinds of EBI: population in viewshed of the natural area (primary demand); percent of that population's viewshed that is natural (scarcity); the number and extent of substitute viewsheds for this population (substitutes); the presence of roads, trails, boatable surface waters, public lands, and access points that allow the natural area to be viewed (complements).

In general, EBIs should be specific to the ecosystem service and benefit in question. Consider two different ecosystem benefits: recreational angling and provision of clean drinking water. The EBIs relevant to these two benefits will be different. In both cases, the number of people benefiting is relevant, but the populations are different. Demand for recreational angling would involve assessment of the number of potential anglers. This population is different from the population benefiting from a given aquifer's water quality. The determination of scarcity and substitutes is very different as well. All of these examples of EBIs can be mapped and counted using geo-coded social (e.g., census) and biophysical data.

<u>Brief Description</u>

EBIs are countable landscape features that tell us about demand for, scarcity of, and complements to particular ecosystem services. EBIs are quantitative inputs to valuation methods. They can serve as important inputs to valuation methods as diverse as citizen juries and econometric benefit transfer analysis, which is a monetary weighting technique. EBIs provide a way to illustrate ecological benefits in a specific setting. For example, if water is available at a particular place and time, how many water users (e.g., recreationists, farms) are present to enjoy that service? What other sources of water are available to those same users? These questions are central to economic valuation of the resource.

<u>Key inputs -</u> EBIs are drawn mainly from geospatial data, including satellite imagery. Data can come from state, county, and regional growth, land-use, or transportation plans; federal and state environmental agencies; private conservancies and nonprofits; and the U.S. Census.

<u>Key outputs -</u> Spatially specific measures (both geo-coded data and corresponding visual depictions) of social and biophysical features that enhance or decrease the desirability of particular ecosystem services.

<u>Scale</u> - The method is entirely scalable. One strength, however, is the ability to relate ecological and economic features in a specific landscape context. For example, the method can

be applied to individual projects, investments, or decisions made in a particular watershed. They can also be expressed as local, regional, state, or national aggregates.

Example of How the Method Could be Used as Part of the C-VPESS Framework

The method relates to a step in the integrated and expanded approach recommended by the SAB Committee on Valuing the Protection of Ecological Systems and Services for "Characterization of the Value of Changes in Monetary and Non-Monetary Terms." Benefit indicators are countable features of the physical and social landscape. More specifically, they are features that influence – positively or negatively – ecosystem services' contributions to human well-being. The consumption of services often occurs over a wide scale. For example, habitat support for recreational and commercial species, water purification, flood damage reduction, crop pollination, and aesthetic enjoyment are all services typically enjoyed in a larger area surrounding the ecosystem in question. EBIs help people understand the larger social and physical landscape so that they can better assess the relative importance of particular services in particular places at particular times.

The value of ecosystem services is likely to be affected by the following factors: the ecosystem feature's scarcity, natural and built substitutes, complementary inputs, and the number of people in proximity to it. For a given ecosystem service scarcity, substitutes, complements, and demand can be related to landscape characteristics. Landscape features that relate to human well-being can be systematically counted and mapped, and then aggregated into bundles of indicators (an index). Some indicators are biophysical, others relate to the socio-economic environment.

Benefit indicators are an input to a wide variety of trade-off analysis approaches, but do not independently make or calculate the results of such trade-offs. First, they can be used as ends in themselves as regulatory or planning performance measures. Second, they can be used as part of public processes designed to communicate the implications of a change or policy across a variety of scales. Indicators or an index based on them can then be used to elicit public preferences over environmental and economic options – as in mediated modeling exercises or more informal political derivations. In this way, benefit indicators are a potentially powerful complement to group decision processes. Third, they can be used as *inputs* to economic and econometric methods such as benefit transfer, or stated preference models. This is an area where research is needed. Economic methods must be developed to link indicator outcomes to dollar-based valuation in a way that is both statistically and theoretically sound. In principle, benefit indicators could be used to calibrate the transfer function in benefit transfers. They could also be used to systematize alternative choice scenarios in choice experiments and stated preference surveys.

As a method to inform the weighting of ecosystem services in a social decision context, the benefit indicators method requires information provided by the biophysical sciences. The method requires spatially depicted biophysical endpoints. EBIs are then related to those endpoints.

The method can be applied to any ecosystem service benefit where benefits are related to the spatial delivery of services and social landscape in which the benefit is enjoyed. Existence benefits (where spatial location is irrelevant to both provision and value) are the only ecosystem benefit category where the method would be inapplicable.

The data used in EBI analysis is well-suited to delivery via a national data bank.

<u>Status as a Method</u>

The method is new and thus relatively undeveloped. EPA has funded a small amount of research on the topic. For citations to peer reviewed research, see below.

<u>Strengths/Limitations</u>

EBIs are designed to be a relatively non-technical way to express the factors that contribute to conventional economic measures of benefits provided by ecosystem services. Their simplicity, and transparency, is an advantage. They can be used to communicate and educate. By stopping short of monetary estimation of benefits (unless integrated in a benefit function transfer method) they are also a way for the agency to overcome resistance to economic assessments of the natural world – while still conveying outcomes in a way designed to be consistent with economic principles and the dependence of human well-being on natural assets.

The principle disadvantage is that they do not directly yield dollar-based ecological benefit estimates. They also do not in themselves weight or estimate the trade-offs associated with different factors relating to benefits (though as noted previously they can be married to more formal methods designed to do such weighting).

Because indicators can be cheaper to generate than econometric value estimates they better allow for landscape assessment of multiple services at large scales.

Treatment of Uncertainty

A core rationale for the use of a benefit indicator approach is to explicitly convey the sources of complexity – and hence uncertainty – characterizing biophysical systems and the benefits arising from them. The visual depiction of benefit indicators, for example, can mimic sensitivity analysis by presenting a range of benefit scenarios in GIS form. However, the visual depiction of quantitative information introduces uncertainties of its own. In particular, visual depictions can strongly influence perceptions. Uncertainty with regard to how indicators are perceived, particularly when presented visually, should be acknowledged.

Research Needs

- Integration of EBIs with biophysical endpoints
- Integration of EBIs with econometric valuation methods (benefit function transfer, stated preference and choice modeling)
- Suitability for group decision techniques, such as mediated modeling
- Practical application to illustrate data needs and measurement issues

Satisfying these needs would be a significant undertaking in terms of expertise, financial resources, and coordination within the agency.

References

Boyd, James, 2004.What's Nature Worth? Using Indicators to Open the Black Box of Ecological Valuation. *Resources*.

Boyd, James and Lisa Wainger. 2002. Landscape Indicators of Ecosystem Service Benefits. *American Journal of Agricultural Economics* 84.

Boyd, James, Dennis King, and Lisa Wainger. 2001. Compensation for Lost Ecosystem Services: The Need for Benefit-Based Transfer Ratios and Restoration Criteria. *Stanford Environmental Law Journal* 20.

Wainger, Lisa, Dennis King, James Salzman, and James Boyd. 2001. Wetland Value Indicators for Scoring Mitigation Trades. *Stanford Environmental Law Journal* 20.