Environ. Sci. Technol. **2010,** *44,* 1530–1536

Accounting for Natural Resources and Environmental Sustainability: Linking Ecosystem Services to Human Well-Being

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Received August 27, 2009. Revised manuscript received December 22, 2009. Accepted January 5, 2010.

One of society's greatest challenges is to sustain natural resources while promoting economic growth and quality of life. In the face of this challenge, society must measure the effectiveness of programs established to safeguard the environment. The impetus for demonstrating positive results from government-sponsored research and regulation in the United States comes from Congress (General Accountability Office; GAO) and the Executive Branch (Office of Management and Budget; OMB). The message is: regulatory and research programs must demonstrate outcomes that justify their costs. Although the concept is simple, it is a complex problem to demonstrate that environmental research, policies, and regulations cause measurable changes in environmental quality. Even where changes in environmental quality can be tracked reliably, the connections between government actions and environmental outcomes seldom are direct or straightforward. In this article, we describe emerging efforts (with emphasis on the role of the U.S. Environmental Protection Agency; EPA) to frame and measure environmental outcomes in terms of ecosystem services and values—societally and ecologically meaningful metrics for gauging how well we manage environmental resources. As examples of accounting for outcomes and values, we present a novel, low-cost method for determining relative values of multiple ecosystem services, and describe emerging research on indicators of human well-being.

Introduction

We measure our nation's economic performance with indicators such as the Gross Domestic Product (GDP), indices of stock and commodity markets, and many others. The reliability, utility, and popularity of these indicators are rooted in what they have in common: units that are easily measured, understandable to anyone, and comparable across sectors—typically dollars. In contrast, we lack a broadly accepted suite of indicators for environmental performance, and those we employ are measured in a menagerie of units ranging from acres (e.g., extent of forests and wetlands) to μg/L (contaminant concentrations in water), and scales ranging from a single point in space to continental and global. Moreover, indicators of quantity do not translate directly or intuitively into indicators of quality. Everyone knows the worth of a dollar, but how does the value of one wetland or coral reef compare to another? It is even more challenging to compare values across ecosystems; what are the relative values of forests, prairies, estuaries, etc.? Taking the question another step, if a quantity goal (e.g., no net loss of wetlands) is achieved, what is gained in terms of environmental quality and value to society? These are difficult questions, for both science and society. We propose a structured approach to environmental accountability, pointing out the needs and challenges along the way. The simple model has four major components: policy, goals, measures (metrics, indicators, values), and monitoring (Figure 1). Most of our emphasis is on developing appropriate measures, including (1) a novel, efficient approach to combining magnitudes and values of ecosystem services into a comparative index, and (2) the concept of an integrative indicator of human well-being. This work arises from the goals of EPA's Ecosystem Services Reseach Program (ESRP): to quantify the values of ecosystem services and provide resource managers, planners, government decision-makers, and others with information such as a national atlas of ecosystem services, interactive maps, and predictive models that will help them to (a) assess management options, costs, and constraints in the context of ecological benefits, (b) sustain, enhance, and be accountable for valuable ecosystem services, and (c) measure the worth of ecosystem services to human health and well-being (*1*).

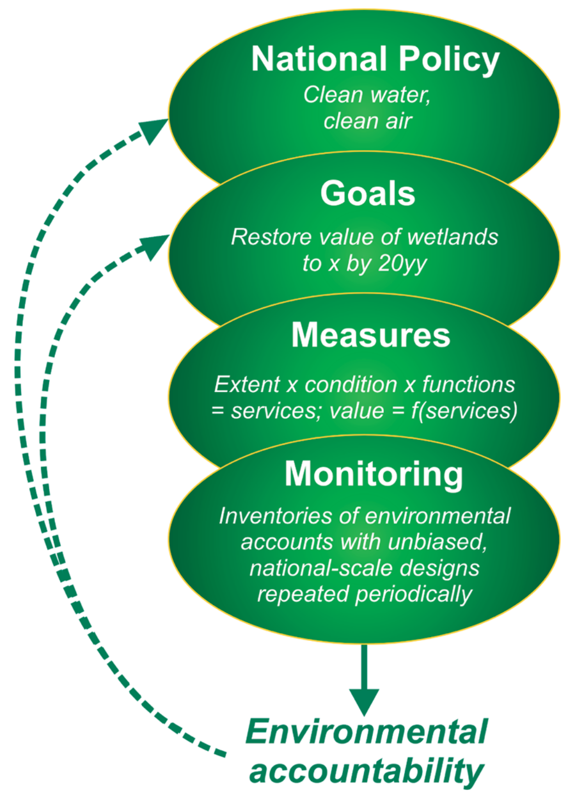

FIGURE 1. A conceptual model of environmental accountability, showing the relationships among policy, goals, indicators of ecosystem services, and monitoring.

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10.1021/es902597u
Published on Web 02/04/2010

For the purposes of this article, we define *metrics* as properties of the environment that can be measured directly, e.g., the nitrate concentration of a body of water or the number of species inhabiting a specific area. *Indicators* are individual metrics or composites of multiple metrics that account for the status of a system or subsystem. The EPA has defined environmental indicators as "numerical value[s] derived from actual measurements of a pressure, state or ambient condition, exposure, or human health or ecological condition over a specified geographic domain, whose trends over time represent or draw attention to underlying trends in the condition of the environment." (*2*) By value(s), we mean economic value in the broadest sense, i.e., the worth of natural capital and ecosystem services to humans and society, whether expressed in monetary or other terms.

A Structured Approach to Environmental Accountability

I. Policy Frames Environmental Accountability. The Nation's premier environmental statute is the National Environmental Policy Act (NEPA) (*3*) of 1969, in which Congress laid out a bold, comprehensive statement of policy, worth repeating here: "... *it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may -*

1. *fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;*
2. *ensure for all Americans safe, healthful, productive, and aesthetically and culturally pleasing surroundings*;
3. *attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences*;
4. *preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and variety of individual choice*;
5. *achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and*
6. *enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources."*

Had these policies been fully successful, there would be no need today to discuss environmental accountability, or to strive for better public understanding and stewardship of our ecosystems and the services they provide to society. Clearly, this is not the case. Some aspects of the environment have improved greatly since 1969, as a result of enforceable water and air quality standards, reductions in loads of persistent toxic pollutants, improvements in waste management, and other actions. Nevertheless, there remain serious concerns, both persistent and emerging, about depletion of natural resources (e.g., groundwater and fisheries), loss and degradation of sensitive ecosystems (e.g., wetlands and coral reefs), climate change, declines in biodiversity, and the potential ecological and health hazards of novel pollutants such as pharmaceutical compounds and nanoparticles.

II. Goals Specify Environmental Outcomes. As the Millenium Ecosystem Assessment (*4*) reminded us, without ecosystem services, there would be no human life, much less human society, economies, or well-being. Given that the null model is unacceptable, what levels of services need to be sustained? That is a scientific question, but society at large, aided by science, needs to decide the kind of world we want to live in. Once society has set goals, the scientific process is responsible for making the connections between needs and desires (policy) and observations (knowledge). The crux of this discussion of accountability is: what do we measure and how do we interpret the measurements so that knowledge can best inform policy?

As an example of the process, in 2000, the Chesapeake Bay Program's Executive Council adopted a goal to achieve a 10-fold increase in the Bay's oyster population by 2010 (*5*). At the time, although monitoring programs were in place, it was not known how to measure a 10-fold increase, or the baseline against which to gauge progress. The public perception of a drastic decline and the need for rebuilding the oyster resource was based almost entirely on historical landings from the commercial fishery. Because the motivations for the oyster restoration goal were as much ecological as economic, fishery performance was not a suitable measure. The policy drove the science to establish a quantitative baseline, measures of oyster population size derived from monitoring programs, and models for predicting future population size based on alternative management scenarios (*6, 7*). This example points to a central principal in the discussion of environmental accountability: indicators need to be grounded in, and benchmarked by, society's goals and public policy (*8*). Whether a particular policy is sound, or a specific goal is attainable, are questions outside this discussion.

Although this example is one of many, it illustrates the important principles that, first, society must decide what it wants, expressing goals and expectations in measurable terms. In the policy development phase, scientists should be consulted about what is measurable and what is realistic, but they do not make these decisions. A goal to send a man to the moon within 10 years probably was regarded as ridiculously optimistic by some scientists in 1961, but this policy, as expressed by President John F. Kennedy, was responsible for advances in science and technology that were barely imaginable at the time. This was the right kind of policy-based goal: bold, measurable, and time-bound. Although the task was difficult in the extreme, it was simple to measure success—either people landed on the moon or not—and to perceive the connections among policy, actions, and outcomes.

In the environmental realm, the commitment of the U.S. to "no net loss" of wetlands is a familiar example. Measuring the results of this policy, established by Presidents Reagan and G. H. W. Bush in 1989 and extended by President G. W. Bush in 2004, is more difficult than it might appear. The total area of wetlands has been estimated once a decade by the U.S. Fish and Wildlife Service from satellites and aerial photography (*9*), so the policy is measurable in terms of acreage. But there are many kinds of wetlands, ranging from vast coastal marshes to seasonal woodland pools, each of which serves a variety of ecological functions and supplies essential services. Some are protected under state and federal laws, and some are not. Because wetlands vary greatly in their functions and the resulting ecological services, tracking acreage serves only the letter, not the spirit of the policy.

III. Measures—The Units of Environmental Accounting. *III.i. Background and Challenges for Measuring Environmental Values.* Underlying the value of ecosystem services is the asset value of the natural resource base (the stock of forests, wetlands, minerals, fish and game populations, etc.). As nonrenewable resources disappear, their services become more valuable. Currently, our national income accounts do not reflect changes in these natural assets. A recent forum, convened by the GAO and National Academy of Sciences, called for development of environmental accounts that incorporate environmental degradation, which can be linked to economic or social consequences (*10, 11*). For example, what is the value of protecting wetlands, mangroves, and coral ecosystems; moreover, how do changes in their extent, structures, and functions affect ecosystem services that in turn affect human well-being? Until recently, evaluating and managing the effects of human activity on ecosystems and the impacts of environmental attributes on human health

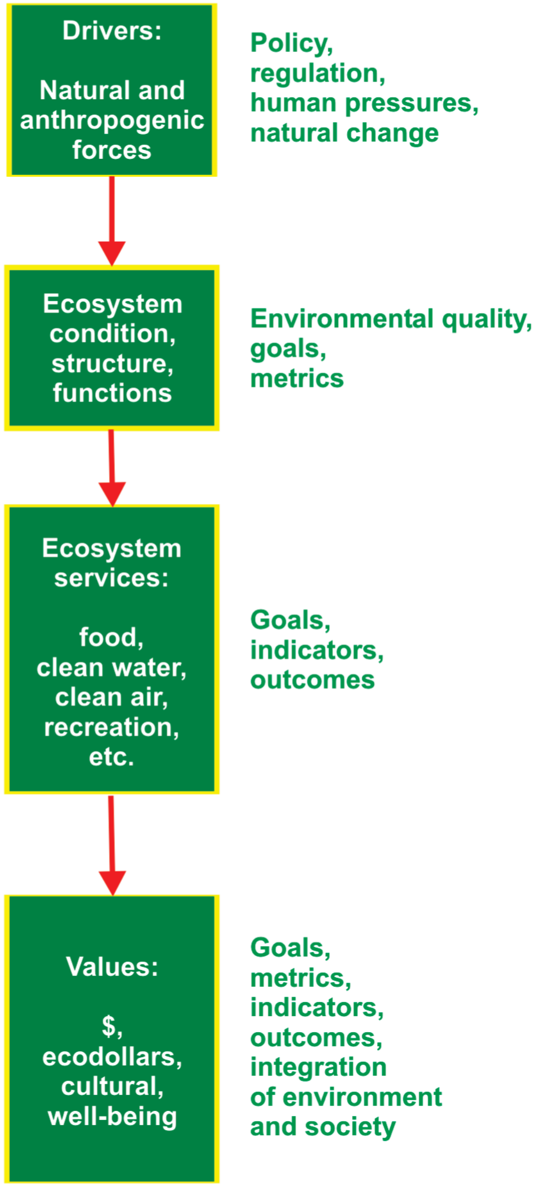

FIGURE 2. Relationships of ecosystems and ecosystem services to human well-being. This diagram suggests a framework for research to improve understanding of the relationships, and is a complement to the conceptual model in Figure 1.

and welfare have been undertaken largely as separate activities, and treated as fundamentally distinct phenomena under the purviews of disciplines that have little interaction (*12*). The interconnection of ecosystems and human well-being, depicted in Figure 2, was clearly a focus of the MEA (*4*). EPA's Office of Research and Development has adopted this general conceptual model for assessing the services associated with wetlands and other ecosystems in the ESRP (*1*).

The ecosystem services paradigm offers a path toward accounting for the values, not just the extent or local quality, of our ecosystems. Where ecosystem products or services are traded in markets, their values can be expressed directly in dollars, for example, the contribution of ecosystems to production of timber, fisheries, and agricultural products. In cases where the dollar value of services is not so easily discerned (e.g., provision of habitat and aesthetics) alternative valuation methods are required. There are many examples of government agencies, communities, and others developing indices of environmental indicators to illustrate the relative health of their natural resources (see the South Florida "Report Card" (*13*), EPA's National Coastal Condition Reports (*14*–*16*), and the academically sponsored Environmental Performance Index (*17*) for example), but these indices are not comparable in common units. The European Commission is synthesizing various approaches to defining and measuring values of ecosystem services. The Commission's report, *The Economics of Ecosystems & Biodiversity* (*18*), brings to light pressing issues that we face in accounting for ecosystem service values, including the role that biodiversity plays in dampening the impact of poverty, and the ethical and monetary implications of using discount rates in economic analysis of ecosystem services.

TABLE 1. Methods for Measuring Environmental Values (Modified from (*19*))

method	observed behavior	hypothetical
direct	market price simulated markets	contingent valuation
indirect	travel cost hedonic property values hedonic wage values avoidance expenditures	attribute-based models conjoint analysis choice experiments contingent ranking

Environmental accounts based on the values of ecosystem services, although intuitively attractive, pose at least two important technical challenges. First, the indicators we can measure with reasonable cost and repeatability are related to services through a variety of difficult-to-measure functional processes. For example, oceans, wetlands, forests, and grasslands contribute to the service of climate regulation (by sequestering carbon) through the processes of photosynthesis, chemosynthesis, growth, and organic matter deposition, weighted by the greenhouse gas (CO_2 and CH_4) regenerating processes of respiration and decomposition. To measure all of these processes requires intensive, site-specific studies, so for accounting at large scales we might measure only plant biomass and soil or sediment carbon, and use estimates or models based on prior studies to quantify the service. Second, translating services to values can be laden with uncertainties.

How can monetary and nonmonetary values of ecosystem services be expressed in a common metric, so that society can make choices among them—e.g., is it more valuable to leave a wetland in its natural state, or fill it for a competing use? Ideally, economists would use available valuation methods to assess how human welfare changes as ecosystem services change with different policy alternatives. Original economic valuation studies are expensive and time-consuming, and if they involve surveys conducted by government economists with public funds, they are subject to approval by OMB—a process known to take years to complete. Alternatively, the results of past valuation studies can be adapted and applied to new ones by value (benefits) transfer, if various conditions are met. However, most valuation studies in the literature are specific to a particular location with unique biophysical attributes. They also include differing sets of ecosystem services, enjoyed by households from various demographics. These factors limit applications to new research.

There is an extensive and expanding literature on economic valuation of natural resources and ecosystem services. See, for example, the book by Freeman (*19*), and articles by Naveh (*20*), Heal (*21*), and Dasgupta et al. (*22*). The methods described include direct and indirect methods, applying both observed behavior and hypothetical markets. Table 1 identifies the major techniques currently employed (except for value transfer, discussed above). Some authorities have made strong arguments against using monetary values or prices to weigh nonmarket ecosystem services such as biodiversity in public decision-making (*23*). The relative valuation method described below is not offered as a complete answer to the problem of accounting for ecosystem services, but rather as a tool to assist with this accounting and to inform decisions about altering landscapes.

III.ii. An Efficient Approach to Measuring Environmental Values. We have developed an index that will enable communities, organizations, or governments to assess the value of ecosystem services expeditiously, without the investment of significant resources. This tool can account simultaneously for multiple ecosystem services, and express the value either in relative units or in dollar-based units. The Relative Valuation of Multiple Ecosystem Services Index (RESVI), applies an estimate for the value of one ecosystem service from the existing economic literature, and scales it by a particular community's rankings of services and the relative yield of services by landscape type. It melds scientific information about ecosystem services with the public's preferences, resulting in a yardstick with which to measure sustainability. The resulting indices, expressed in what we term "ecodollars", can be used to portray the directionality and magnitude of changes in services, given alternative future scenarios, and to assess the benefits and costs of conserving some services and not others. Applying a dollar value from the scientific or economic literature to one service for one landscape type yields ecodollar estimates for all ecosystem services, requiring significantly less time and resources than traditional economic valuation. The resulting index should not be interpreted as based on traditional willingness-to-pay methods; rather it takes a value for one ecosystem service from the literature (value transfer) or original research and weights it by stakeholder preferences for a variety of ecosystem services, and the relative provision of services by landscape types. It can be viewed as a management tool that points to resources and services to which more attention should be paid. Background information on methods of environmental valuation, along with a theoretical justification for the RESVI approach can be found in the Supporting Information.

In summary, the RESVI method consists of (1) briefing participants about the policy question to be addressed, describing the extent and nature of the ecosystem(s) involved, and supplying information about the relevant ecosystem services; (2) asking each participant to assign relative values to a suite of ecosystem services, e.g., what portion of a dollar would you spend for recreational amenities versus water supply?; (3) applying an absolute reference value (in dollars) from the literature or primary research to one service from one landscape type, e.g., water filtration by wetlands; and (4) indexing all services using the reference value and the relative values assigned by the participants. The values can then be scaled to the landscape with knowledge of (1) the relative or absolute provision of services by each landscape type, and (2) the areal extent of each landscape type in the parcel or region under study.

The RESVI method was employed three times, twice as a pilot, and once in a more operational mode. The first pilot test was conducted June 25, 2008, at the offices of EPA's Gulf of Mexico Program (GMP), located at Stennis Space Center, MS; the second was September 30, 2008 at EPA's Gulf Ecology Division (GED) in Gulf Breeze, FL. The third test was conducted December 12, 2008 in Tampa, FL with a group of interested parties from the region. The last of these tests was conducted in support of a specific ESRP project, in which inventories, maps, and predictive models of ecosystem services in the Tampa area are being developed (*24*). Nine GMP staff, 15 GED staff, and 14 individuals from the Tampa Bay region participated in the tests. The GMP staff were mostly senior EPA scientists and policy analysts who had

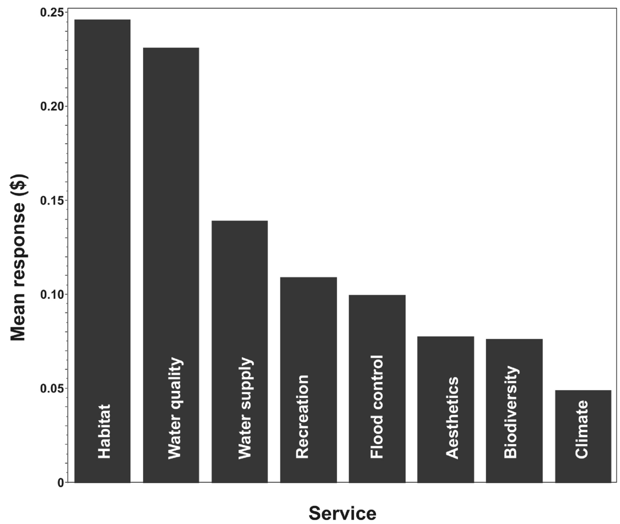

FIGURE 3. Overall mean relative values for three groups of respondents. Habitat = habitat functions; Water quality = water quality regulation; Climate = climate regulation.

worked in the environmental field for ten or more years, and were familiar with the environmental problems affecting the Gulf of Mexico and its ecosystems. The GED group was similar in composition, but also included technicians and administrative staff. The Tampa group included participants from the Tampa Bay Regional Planning Commission, Tampa Bay Estuary Program, area universities, and county environmental managers. Thus, our examples are not from random or diverse cross sections of society, as would be necessary for large-scale application, but they do illustrate the method.

In these pilot examples, we used value transfer, with a single monetary value from the literature, to generate a value scale for the preferences: a median value of coastal wetlands for flood protection of \$3230 $\cdot$ ha$^{-1}\cdot$yr^{-1} (*25*). Relative provision of ecosystem services by landscape type was estimated using professional judgment; in practice, this step would require one or more ecological production functions (the quantitative delivery of ecosystem services per unit area) for each service within each land use type. Detailed methods and raw data for the RESVI applications are contained in the Supporting Information.

The test groups valued habitat functions and water quality more than other selected ecosystem services, whereas they consistently attributed the lowest values to climate regulation (Figures 3 and S1 Tables S1, S2, S3). The integrated and scaled values shown in Figure 4 illustrate how RESVI could be applied in a public decision-making process. Although the example is partially hypothetical (because the production functions were imputed), the high values for wetlands and forests relative to urban landscapes show how the values of ecosystem services could balance or offset the typically higher market values of urban lands. In our example, a choice to convert 1 ha of forest to urban development predicted a negative annual value (cost) in ecosystem services of 25,150 ecodollars. Although we emphasize that this value should not be interpreted as real dollars, it is within a reasonable range from a monetary perspective.

III.iii Accountability in Terms of Human Well-Being. The valuation index is one example of a new generation of indicators, taking us beyond the tradition of accounting in terms of environmental programs, projects, activities, and expenditures into the realm of true accountability. Dollar values, or surrogates such as ecodollars, meet the tests of common units and universal comprehension. Yet we also need to account for the intrinsic value of ecosystems and how they serve human well-being. Defined as "a good or satisfactory condition of existence; a state characterized by

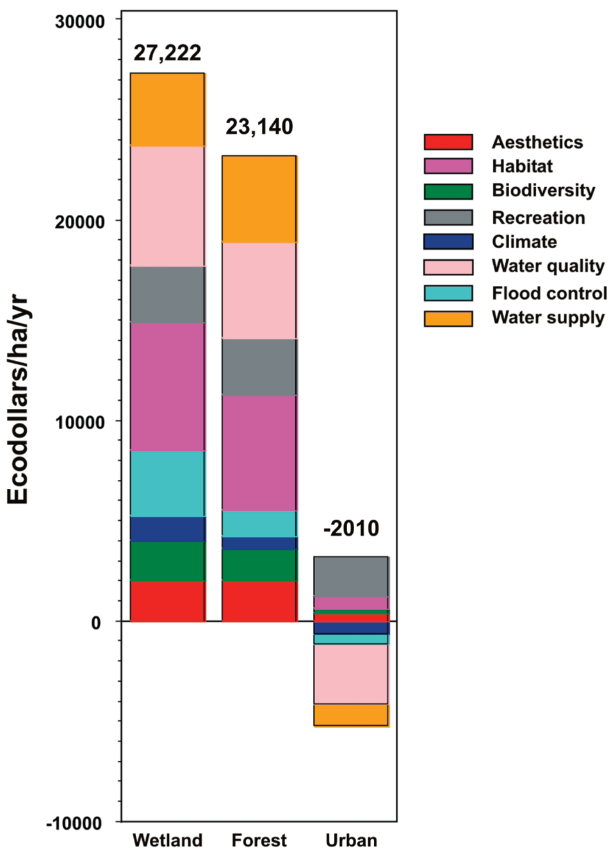

FIGURE 4. Relative Ecosystem Services Valuation Index in annual ecodollars/ha for 3 generalized landscapes. Responses of 3 test groups were combined; a single dollar value from the literature was applied to the flood control service (*25*); relative provision of services from each landscape was estimated by professional judgment (Table S4). The values above each column are total ecodollars for each landscape type. Negative values of ecosystem services for urban land arise from the deleterious effects of contaminated runoff, wastewater, impervious surfaces, atmospheric emissions, and heat generation on water quality, flood protection, water quantity, and climate regulation.

health, happiness, and prosperity; welfare" (*26*), well-being is a holistic concept incorporating human connectedness to natural systems, and it is at the core of policy development. Well-being, therefore, should be the ultimate measure of accountability for environmental decisions. If EPA is "to improve the way we account for the type, quality and magnitude of the goods and services we receive from ecosystems in every day environmental management decisions" (*1*), there is a need to quantify end points that reflect overall human well-being.

The conceptual relationship of the quality of the environment and its services to human well-being is well established and generally accepted (*27*). Nevertheless, establishing these values in quantitative terms is more elusive and requires broader thinking than more straightforward (yet still difficult) economic approaches (*28, 29*). For example, Dasgupta in ref *27* discusses the complexities involved in relating biodiversity to well-being. The "well-being" term in Figure 2 suggests a suite of indicators that could be used to measure and account for well-being, i.e., human health, security, materials for a good life, social relations, and freedom of choice and action. These indicators are linked to ecosystems individually and directly, through the provision of services, and also, in an integrated way, through the combined values of the services. To account for well-being in environmental decisions, we need to venture beyond natural sciences and economics into the psychological, political, and sociological realms.

A number of "alternative currencies" has been suggested that could be used to represent the value of ecosystem services to society. These include, among many examples, emergy (*29*), happiness indices (*30*), indices of the quality of life (*31*), and well-being indices (*32*). Subjective and empirical measures are needed to evaluate well-being, therefore well-being indicators are inherently categorical and best represented as a range (*33*). A generalized index of well-being, independent of time, place, and culture, is needed to unify a range of human and environmental domains. At a minimum, a well-being index should integrate subjective and objective information, be applicable to multiple ecosystems, and have transferability among geographic locations.

Drawing from the literature and the numerous examples of national level indices, EPA and partners are developing an Index of Human Well-Being (IWB), designed to be responsive to changes in ecological services at multiple scales. The proposed IWB is a composite index with a four-pillared structure (*34*) based on (1) *basic human needs,* (2) *environmental needs,* (3) *economic measures,* and (4) *happiness*, indicators that map to the MEA constituents of well-being (*4*). An IWB will integrate information on many dimensions of health, welfare, and subjective well-being, accounting for how they change in response to changing environments. Developing and applying an IWB will pose multiple challenges, but if we ignore these challenges, national environmental programs will lack genuine accountability. More than knowing what ecosystems are worth in economic terms, we have the opportunity to understand how they serve the human condition.

IV. Monitoring—The Means of Environmental Accountability. Finally, given sound environmental policies, measurable goals, and suitable indicators, accountability requires consistent, reliable monitoring and assessment at local, regional, and national scales (Figure 1). This may be the greatest challenge of all. Any private enterprise that could not keep rigorous track of its inventory and accounts would soon fail, yet the United States lacks an integrated environmental monitoring program.

Although federal environmental statutes specify various kinds of reporting and monitoring, the mandates generally are aimed at measuring legal compliance rather than environmental outcomes. So, how do we evaluate whether these laws work and are, in fact, operating to meet the Nation's environmental policy goals and the Agency's mission—to protect the environment and safeguard human health? The EPA derives its regulatory authority from statutes such as NEPA (*3*), the Clean Water Act (*35*), the Clean Air Act (*36*), Superfund (*37*), and several others, managed through various national programs and regional offices. Metrics such as counts of rules, permits, regulations, and guidance advisories are important outputs, but not actual performance metrics that support evaluation of how Agency actions affect environmental quality. Although environmental data are collected at various national and subnational levels, limitations in the data diminish their value to policymakers. These data vary in quality, and often are spatially and temporally inconsistent and lack comparability, resulting in a lack of key national environmental indicators to understand or measure comprehensively the state of the environment or how it is changing over time.

In the direction of greater accountability, EPA's Environmental Monitoring and Assessment Program (EMAP) (*38*) has assessed ecological conditions in lakes, rivers, streams, and estuaries nationally; as an example we cite the National Coastal Condition Reports (*14–16*) of the condition of all U.S. estuaries. These reports are compilations of diverse information closely linked to environmental quality outcomes; indices of water quality, sediment quality, benthos, coastal habitats, and fish tissue are used as indicators to assess coastal condition, then aggregated into overall quality indicators with both numeric ranks and nominal scores (good, fair, poor). This approach, simple in concept, but complex in execution, has supported assessments of environmental performance that are comparable over time and geographic scales, including the national scale. These reports are important achievements in the direction of accountability, but the measures are incomplete from an ecological perspective, and have proven difficult to relate to actions, regulatory, remedial, or otherwise. The question of accountability is particularly difficult at the level of ecosystems—the 2008 Report on the Environment states, "The ability to report on ecological condition remains significantly limited by the lack of indicators..." (*39*).

The EMAP has demonstrated the feasibility of measuring the condition of aquatic ecosystems at state, regional, and national scales, and other national monitoring programs either are active or proposed. None of these programs, however, either singly or in combination, has achieved the level of integration and sustainable support required to (a) account for our investments in environmental protection and restoration, (b) determine the extent to which the services and values of our ecosystems are being sustained, or (c) gauge how changes in ecosystems affect human health and welfare.

Discussion

We have presented a model of environmental accountability and an outline of a process for achieving it. Like all models, it is an abstraction and simplification of a more complex system. One aspect of our abstraction is the division of the problem into four discrete, albeit overlapping, steps as shown in Figure 1. At a less abstract level, each oval in Figure 1 contains a number of subtasks (e.g., translating ecosystem services to values) that need to be accomplished, and overall, the process is continuous and not necessarily as sequential as portrayed. Goals can drive policies and measures can shape goals, for example. Nevertheless, we favor the top-down model. It asks the questions in order: why are we accountable (policy), what are we accountable for (goals), how do we do the accounting (measures), and what is the current status of our accounts and how are they changing (monitoring)?

Achieving and maintaining a sustainable environment requires more than accounting. Actions, including legislation, regulation, mitigation, resource management, enforcement, education, and social responses to environmental challenges are the dynamic forces that produce results. Environmental accounting can only tell us what those results are, and, following the ecosystem services paradigm, what they're worth and how they serve humanity.

Human well-being and sustainable ecosystems are entirely interdependent. This concept has been recognized in national policy and legislation for many years. We cannot, however, know the full effects of environmental policy without: (1) goals linked to policy that are quantitative, time-bound, and grounded in relative or absolute values; (2) indicators linked directly to the goals, measurable in common units, and expressive of real values to the economy and society; and (3) consistent, scalable, sustainable monitoring and assessment of the extent, condition, and functions of ecosystems. In recognition of these realities, EPA is working with a large number of public and private partners to develop the methods to measure and account for the values of ecosystem services to society's health, wealth, and well-being (*1*). The intersection of society and the environment ultimately will determine the success of the human enterprise, nationally and globally, and it is critical to know where we stand.

Acknowledgments

This article was inspired by the vision of Rick Linthurst, EPA's National Program Director for Ecological Research, in redirecting the program toward ecosystem services and human well-being, and the senior author's experience in promoting a stronger role for ecology in EPA's decision processes. We thank all of the participants in our RESVI pilots for their time and cooperation. Drs. Marisa Mazzotta and Syma Ebbin, and staff from EPA's National Center for Environmental Economics contributed thoughtful preliminary reviews. The information in this document has been funded wholly (or in part) by the U.S. Environmental Protection Agency. It has been subjected to review by the National Health and Environmental Effects Research Laboratory and approved for publication. Approval does not signify that the contents reflect the views of the Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. This is contribution number 1348 from the Gulf Ecology Division, a product of EPA's Ecosystem Services Research Program.

Supporting Information Available

Theoretical justification for the RESVI index, detailed methods for its construction, and complete data from the pilot applications of RESVI. This information is available free of charge via the Internet at http://pubs.acs.org/.

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ES902597U