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Fundamentals of Estimating the Net Benefits of Ecosystem Preservation: The Case of the Salton Sea

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This paper has not been submitted elsewhere in identical or similar form, nor will it be during the first three months after its submission to *Hydrobiologia*.

Abstract

This article, both theoretical and methodological in nature, argues the potential merits of using a net benefits framework as a tool to aid policy makers in their efforts to compare Salton Sea restoration alternatives and inform the public as to the potential magnitude and distribution of trade-offs associated with each alternative. A net benefits approach can provide a more accurate comparison and evaluation of the potential net returns from public spending on Salton Sea restoration than what would be provided under the suggested criteria of current legislative mandates. Furthermore, a net benefits framework provides a more lucid and systematic accounting framework by which to enumerate the full array of benefits and costs of each alternative for policy analysis. Finally, net benefits analysis serves to add transparency to the decision making process so that the public gains an understanding of how its scarce resources, including both financial and natural capital, are being appropriated. Additionally, we illustrate and emphasize the importance of estimating the non-market values associated with many of the ecosystem services provided by the Salton Sea and describe the major techniques that do so.

Introduction

The objectives of this article are two-fold. First, we emphasize the potential merits of using a net benefits framework as a tool to aid policy makers in their efforts to compare Salton Sea restoration alternatives and inform the public as to the potential magnitude and distribution of trade-offs associated with each alternative. A net benefits framework is a framework that uses the differences between the benefits and costs of a policy or action as a means of comparison. Currently, legislation mandates that the Secretary of the Resources Agency for the State of California establish "suggested criteria for selecting and evaluating alternatives" (Section 2081.7 of the California State Fish and Game Code, part (e)). Two explicitly mentioned criteria include an evaluation of the construction, operation, and maintenance costs of each alternative, hereafter referred to as engineering costs, and the identification of a cost-effective, technically feasible option. Relative to these suggested criteria, a net benefits framework can provide a more accurate comparison and evaluation of the potential net returns from public spending on Salton Sea restoration. Furthermore, a net benefits framework provides a more lucid and systematic accounting framework by which to enumerate the full array of benefits and costs of each alternative. Finally, net benefits analysis serves to add transparency to the decision making process so that the public gains an understanding of how its scarce resources, including both financial and natural capital, are being appropriated.

Second, we emphasize the importance of estimating the non-market values associated with many of the ecosystem services provided by the Salton Sea, describe the major techniques that do so, and suggest how these techniques could be applied to the Sea. The Salton Sea is a natural asset that provides many services to society, including unpriced non-market goods and services for bird watching, fishing, boating, and camping. The Sea is home to the endangered desert pupfish, as well as over 400 species of migratory and resident birds, approximately fifty of which have garnered special status as threatened, endangered, or species of concern. These sorts of ecosystem services have been shown to be highly valued by society in other regions around the state, nation, and world, and, accordingly, should be treated as such in any objective economic analyses concerning their use. Indeed, as the National Resource Council (2004) argued recently, assigning a dollar figure to non-market ecosystem services is essential to accurately weight the trade-offs among environmental policy options. Overlooking these values often results in an implicit value of zero being assigned to them in the economic analyses, which is incorrect and unnecessary because numerous analyses exist that have estimated the monetary value of similar services. Wilson & Carpenter (1999), for example, provide a summary of the economic value of freshwater ecosystem services in the U.S., noting 30 refereed published articles in the scientific literature from 1971 to 1997. This literature is quite extensive and includes values derived for all manner of ecosystems, including wetlands, forests, and marine environments.

We begin with a description of the mandate imposed upon the California Resources Agency in its endeavor to identify a preferred alternative. Shortcomings of the process are identified relative to what might be provided by a net benefits framework in evaluating alternative restoration plans. A description of how to perform a net benefits analysis is then provided. Since many of the benefits associated with restoring the Salton Sea reside in the ecosystem services the Sea provides to society, a description of the main non-market valuation techniques used to estimate the value of these services is presented. Summaries of previous studies attempting to value a healthy Salton Sea are provided, including a recent report developing suggestive estimates of the recreation and preservation values using the results from non-market valuation studies of somewhat similar California habitats. Finally, we summarize our findings.

Background and Motivation

The California Resources Agency is mandated to identify a preferred alternative for the restoration of the Salton Sea. As noted by California State Senator Ducheny at recent conference centered on the Salton Sea, this will be no easy task (Remarks by State Senator Ducheny at "*The Salton Sea Centennial Symposium*", San Diego, CA., April 1, 2005). First, the legislature will be required to operate under a set of preexisting rules and regulations that will limit how much financial and natural capital (i.e., water) it can allocate to solving this problem. California has been mandated to adhere to its Colorado River water entitlement of 4.4 million acre-feet, down from the approximately 5.2 million acre-feet it has grown accustom to using. Additionally, as part of the Quantification Settlement Agreement (QSA) signed in 2003, the Imperial Irrigation District has agreed to transfer 200,000 acre-feet of water to San Diego (Cohen & Hyun, 2006).

Second, given the complex set of linkages in the region, mostly driven by water, the effectiveness of any particular restoration alternative will be largely dependent on, or place restrictions upon, upstream users of the water, particularly agriculture. Agriculture, whose drainage flows are responsible for nearly 85% of the inflow into the Salton Sea, will be largely responsible for this cutback; as such, less applied irrigation water will lead to less drainage and thus less inflow to the Salton Sea. Less inflow will strain the effectiveness of any particular restoration solution, and leave more Salton Sea lakebed exposed as shorelines recede. As the area of exposed lakebed increases so will the amount of fine windblown dust in this high wind region which is currently not in compliance with state and federal air quality standards and is characterized by the highest rates of hospitalization of children for asthma in the state (Cohen & Hyun, 2006). Alternatively, requirements for agriculture to maintain historic inflow levels will likely affect the economic health of this very poor region that has nearly 19% of its population considered living in poverty (United State Department of Agriculture, 2004). These impacts may directly affect the productivity and profitability of agriculture and, consequently, labor and income associated with agriculture and agricultural-related activities.

Third, across the feasible set of restoration alternatives there are significant differences in habitat configuration, elevation, and both the quantity and quality of inflow assumed; consequently, each alternative will provide a different array of ecosystem services. Hence, the benefits of restoration are likely to differ depending on the alternative chosen, including those benefits associated with recreation and preservation at the local, state, and national level.

As part of its decision-making process, the Resources Agency will perform a "…restoration study to determine a preferred alternative for the restoration of the Salton Sea Ecosystem and the protection of wildlife dependent on that ecosystem" and report the findings to the legislators (California State Fish and Game Code, Section 2930: 93). Elements of this study are to include:

(a.) an evaluation of restoration alternatives including consideration of salinity control, habitat creation and restoration, and different shoreline elevations and surface area configurations,

(b.) consideration of a range of possible inflow conditions,

(c.) suggested criteria for selecting and evaluating alternatives, including, but not limited to at least one most cost-effective, technically feasible alternative, and

(d.) an evaluation of the magnitude and practicality of costs of construction, operation, and maintenance of each alternative evaluated.

These elements, in addition to providing some necessary bounds on the problem, identify factors that can substantially influence the costs and benefits of any particular alternative. For instance, consider item (b) related to inflow conditions. The engineering costs of the final restoration alternatives considered in the Salton Sea Reclamation Act of 1998 varied between $320 million and $1.4 billion depending on the inflow assumption. While none of the alternatives listed in the 1998 legislation were enacted, the cost estimation exercise did highlight how the engineering costs of any particular alternative depend on the values assigned to possible factor inputs.

Consider the remaining elements listed above. Similar to the 1998 legislation, engineering costs of each restoration alternative are to be estimated and compared (d), yet an explicit call for the identification of a cost-effective solution is to be included (c). Cost-effectiveness typically refers to the least-cost approach to achieving a particular level of environmental quality, or in this case, ecosystem services. Yet, as emphasized in (a), each restoration alternative likely will provide a different array of ecosystem characteristics.

Hence, while the stated intent of the restoration study is to inform policy makers of the potential trade-offs associated with each alternative and it is acknowledged that any particular restoration strategy can deliver a different stream of benefits to society, there is no discussion of how to evaluate and quantify these benefits. Unlike goods that are bought and sold in the marketplace, the economic benefits of natural resources are not revealed through market transactions. The benefits derived from these resources are thus termed “non-market values.” Most of the benefits from restoring the Salton Sea consist of these non-market values (e.g., those values we place on recreation or the preservation of endangered and threatened species).

Implicit in performing a cost-effectiveness analysis or engineering cost comparison is that the benefits are assumed constant across restoration alternatives, in contrast to what is suggested in element (a) above. This is clearly not the case with the proposed alternatives for restoration of the Salton Sea, either in the alternatives proposed in the 1998 legislation, or the eight alternatives listed in the Salton Sea Ecosystem Restoration Draft Programmatic Environmental Impact Report (California State Resources Agency, 2006). Because the California Resources Agency is not required to consider how the returns to each investment will differ relative to the costs, their selection may not allocate resources to their highest valued uses since achieving such efficiency requires a comparison of the costs and benefits of each alternative. The process of itemizing, quantifying, and comparing the costs and benefits is known as benefit-cost analysis. Whether formalized or not, this practice is perhaps the most fundamental tool used in decision-making by individuals, private organizations (e.g., firms), and public institutions (e.g., state governments).

Further, as indicated in the 1998 legislation, the attractiveness of any alternative is inextricably linked to assumptions about the inputs (e.g., inflows), outputs (e.g., level of ecosystem services), and scale of analysis. For instance, what might be considered the cost-minimizing engineering solution may not be the cost-effective alternative when the impacts on regional agricultural production, the regional economy, or human health from poorer air quality also are included. Continuing, what might be the regionally efficient solution may not be the efficient solution from the state perspective, and so on. Given that the state government will be involved, it seems reasonable to assume that the California Resource Agency would consider the local, regional, and statewide impacts in their efforts to choose a preferred alternative. This does not suggest that broadening the analysis even further has no value, though. As Ciriacy-Wantrup (1964) noted, consideration of the broad impacts of a policy may be a preliminary step toward broadening the repayment base—a base which is sometimes rather narrow if confined to primary benefits. Enumerating and quantifying the benefits of Salton Sea preservation to a broader population might be a first step towards justifying federal assistance.

Finally, it is important to note that while the popular press has only recently begun extolling the importance of placing a value on non-market environmental goods and services (e.g., The Economist, 2005, April 3rd-29th: 76-78; Business Week, 2004, December 29th; Infocus Magazine, 2005; 4.3; Outside Magazine, March, 2005: 106-123), these values, and the non-market valuation methods used to estimate them, have been given standing in legislative mandates and by state and federal government agencies for decades, including the Comprehensive Environmental Response, Liability, and Compensation Act (CERCLA) of 1980, the Oil Pollution Act (OPA) of 1990, U.S. Water Resources Council, the U.S. Department of Interior, and the U.S. Forest Service. Federal and state agencies also consider non-market values when making natural resource allocation decisions. Since 1979, for example, the U.S. Army Corps of Engineers and Bureau of Reclamation have been required to assess the value of recreation benefits in cases where federal projects impact areas of high visitation (Loomis, 2005). The U.S. Environmental Protection Agency (EPA) is required to conduct benefit-cost analyses of environmental regulations and must include estimates of non-market benefits. CERCLA mandates that lost recreation values and “passive use” values from toxic waste sites and hazardous materials spills must be assessed in order to measure the full value of damaged natural resources. Many states have funded studies measuring non-market values associated with recreation and ecosystem preservation, including the State of California, which sponsored an analysis of the values of protecting Mono Lake as a bird habitat (Loomis, 2005). Hence, the validity of valuing changes in environmental or natural resource quality and its usefulness in guiding resource allocation decisions has been invoked at state and federal levels.

Net Benefits: Background and Conceptual Issues

As noted above, a commonly employed litmus test in judging whether a project should be undertaken or not is whether it passes the present value benefit-cost test (i.e., whether the present value benefits are at least as great as the present value costs). The formal use of benefit-cost analysis for large water-related projects can be traced back to Eckstein (1958) in his evaluation of federal water-resource programs. In particular, Eckstein (1958: 2) references the Flood Control Act of 1936, which suggests that only projects where “the benefits, to whomsoever they may accrue, are in excess of the estimated costs” would be considered. Eckstein described benefit-cost analysis as a very promising approach for evaluating the use of scarce natural and financial capital that can provide a much stronger foundation for policy decisions than what might otherwise be available. This is especially true when many agencies with jurisdictional overlap are involved in the decision-making process, such as in the case of the Salton Sea. In response to the problems associated with multi-agency involvement and overlap, Eckstein stressed the importance of a general set of standards by which projects can be appraised and compared. Such standards, he continued, would also serve a wider interest in informing the public about the merits of a project and what they will be asked to forego in return.

It should be emphasized that just because the estimated benefits of an alternative are in excess the estimated costs does not mean that this alternative is the economically efficient alternative. Indeed, there may be more than one alternative that meets this condition. Of course, the alternative that is in the best interest of society from an economic efficiency perspective is that alternative providing the highest net benefits, which are defined as the difference between the total benefits and total costs.

Why there has not been greater focus on using benefit-cost analysis or net benefits analysis in the context of Salton Sea restoration is puzzling, especially when such an approach has been prominent for more than 30 years at federal level in consideration of major environmental, health, and safety regulations (Morgenstern, 1997). Under President Clinton’s Executive Order 12866, federal agencies are now allowed to “include both quantifiable measures and qualitative measures of costs and benefits" and to "select those approaches that maximize net benefits (including potential economic, environmental, public health and safety, and other advantages; distributive impacts, and equity)." Furthermore, numerous real world examples exist of governments incorporating the benefits of preserving natural and environmental resources into their decision-making, both in the U.S. and abroad. Such evaluations cover a wide array of resources, including the Glen Canyon Dam (Bishop et al., 1989), Hell's Canyon (Krutilla & Fischer, 1975), Mono Lake (Loomis, 1987), the spotted owl in the Pacific Northwest (Hagen et al., 1992), Kootenai Falls in Montana (Duffield, 1982), and the Kakadu Conservation Reserve in Australia (Imber et al., 1991), to name a few. In these and other studies, the preservation benefits associated with environmental and natural resources were quantified and given standing in benefit-cost analysis. In each case, the quantification of such benefits either supported an action for preservation, or modified an existing development scheme to be more environmentally friendly. In all cases, a large—if not the largest—component of the value of preservation was non-market value.

Before moving on to the various steps involved in estimating the net benefits, it is useful to clarify what economists mean by economic value, especially in the context of environmental and natural resource goods and services. Economic value is defined by what one (or a group) would be willing and able to pay for a good, not by what one has to pay for it—what one has to pay for a good is what it costs, and is considered an expenditure. In contrast to the benefits of an action, the costs of achieving a particular objective can be measured by what is foregone to achieve that objective, and include both direct engineering costs as well as *opportunity costs*. The former includes both current and discounted future costs, and the latter represents the value associated with the opportunity to use the forgone resources in another activity.

We must also recognize that economic value, which is meaningful from an anthropocentric perspective only, extends beyond the marketplace to *non-market goods* such as clean air or water, open space, and wildlife preservation. Furthermore, the economic value of these goods is comprised of both *use* and *non-use* values. The values associated with catching tilapia for consumption and bird watching would be examples of *use* values associated with the Sea, while the value that people derive from knowing that the Salton Sea ecosystem exists for current and future generations would be an example of *non-use* value.

Components of Net Benefits Estimation

For large projects, efforts to estimate the net benefits may seem insurmountable; thus it is best to have a road map as to what might be the necessary steps to perform a net benefits analysis. Borrowing upon previous work (Boardman et al., 1996; Morgenstern, 1997), we present a description of the main steps in performing a net benefits analysis and identify how each step could be applied to the restoration of the Salton Sea.

Specify the portfolio of alternative projects

Finding the efficient solution requires identifying, investigating and comparing numerous alternatives with the outcome that would occur if no action were taken, i.e., the baseline. In the Salton Sea Reclamation Act of 1998, over 50 proposals were identified, of which five were given additional scrutiny, but eventually deemed “too costly and too impractical to implement.” (California Department of Water Resources, 2003: iii). These analyses did prove valuable in that the CDWR, along with other agencies (e.g., USBR, USFWS, Salton Sea Authority), could now focus on a narrower set of feasible alternatives. Currently there are eight proposals to evaluate relative to two “no action” alternatives. These alternatives differ in many dimensions including construction and maintenance costs, strategies for salinity control, shoreline elevations, water body size, depth, salinity, and surface area configurations, and wildlife habitat.

Well-defined objectives and criteria will go far in narrowing the possible choice set. The Salton Sea Restoration Act puts forth the following objectives to be considered when evaluating alternatives: sustain avian biodiversity at the Salton Sea without maintaining elevation of the entire Sea; maintain near-current salinity and elevation; and represent the most cost-effective technical alternative. Regarding this last objective, care must be taken here not to prejudge alternatives too quickly based on *ex ante* costs alone for risk of defining the choice set too narrowly. Because the proposed alternatives provide a wide array of environmental benefits, the most cost-effective solution may not be that which maximizes net benefits.

Decide whose benefits and costs have standing

The benefits and costs of a particular regulation or action can be realized at the local, regional, state, national, and even international level. As Boardman et al. (1996) note, national governments typically consider costs and benefits at the national level. It is not uncommon, though, for cities, municipalities, or states to overlook the impacts of their actions on one another in terms of who counts. Political boundaries and the level of administrative unit will often drive who is included in a benefit-cost study.

With respect to the Salton Sea, many different groups will be directly or indirectly impacted by the choice of restoration alternative, extending from recreational users of the Sea, to the localities around the Sea, to the growers in the Imperial and Coachella agricultural regions, to state, federal and tribal agencies, as well as to those living abroad. A potential difficulty that arises with so many agencies and political boundaries is that what might be efficient at one level of analysis (or political boundary) may not be efficient at another level (or boundary). For instance, a cost-effective restoration alternative might not be cost-effective when the impacts on agriculture or regional employment and income are considered, or when the impacts on human health from dust particles from the exposed seabed are acknowledged. What might be the efficient solution for Imperial County and residents of the Salton Sea might not be efficient for the state of California. Performing a broad-based net benefits analysis to determine the extent of the market would provide transparency as to the distribution of benefits and costs among different stakeholders. This will be useful so that criteria other than efficiency, such as equity, are part of the decision-making process.

Catalogue the impacts and select measurement indicators

Many types of impacts may result from regulatory and policy actions. What is necessary for benefit-cost analysis is to catalog these impacts as either benefits (positive impacts) or costs (negative impacts) and decide upon a measurement unit for the impact. These impacts can be measured in a variety of ways, including economic, environmental, and health effects. Economic indicators include jobs, time, income and changes in consumer and producer welfare. Environmental indicators may include quantitative assessments of species viability, ecosystem productivity, and water and air quality. Indicators of public health might include the avoidance of health care costs or benefits associated with changes in quality or longevity of life.

Such categorization and measurement are certainly suitable for the Salton Sea restoration alternatives. Benefits and costs may accrue to landowners, farmers, local businesses (especially those relying on tourism), recreationists such as bird watchers and anglers, environmental groups, and local and regional governments. While the category of measurement for the engineering costs of restoration will be dollars, each restoration alternative may affect or be affected by upstream activities related to agriculture. That is, the response from agriculture to the reduction in California's take of Colorado River water can affect the inflow volume into the Sea; consequently, additional mitigation activities will be required to offset the reduced volume and surface elevation of the Sea. For instance, as the shoreline recedes due to lower inflow and in lieu of additional mitigation, increased dust and particulates will be generated exacerbating an already exorbitant regional air quality problem.

Alternatively, if the inflow volume is required to remain constant, then presumably agriculture may need to engage in additional water conservation schemes (e.g., reduce applied water rates, more efficient irrigation measures, land fallowing) in order to reduce their applied water rates sufficiently to provide enough mitigation water to maintain inflow volume requirements. These activities can and should be measured in terms of productivity, additional labor hours, income, and employment. The indirect impacts from the restoration alternatives may be very important and thus, at a minimum, should be acknowledged via a categorization of this type. Insight into possible agricultural-related and regional impacts would be further enhanced by applying a regional agricultural production model for agricultural activities (e.g., Schwabe et al., 2006) and a social accounting matrix model (multiplier analysis) to account for the employment and income effects within the region (e.g., Berck et al., 1991).

Additionally, the impacts of the restoration alternatives on ecosystem services should be considered. These impacts will differ by restoration alternative, and thus will have varying effects on tourism and recreation, such as time and income spent on recreating, and wages and income earned from tourism. Such impacts may extend beyond the immediate area, certainly to the state, and perhaps to the nation in terms of non-use values. Indeed, perhaps the largest benefit associated with preserving and restoring the Salton Sea does not necessarily accrue to current users of the Sea, but rather to people that care about the Sea regardless of whether they tangibly use the Sea currently. People have been observed benefiting from environmental resources, and willing to pay to protect them, just by knowing the resources exist. For example, Sanders et al. (1990) estimates what people are willing to pay (i.e., their value) for preserving free flowing rivers with no intention of ever visiting them. Alternatively, Olsen et al. (1991) estimate peoples willingness to pay (value or benefits) for maintaining salmon migrations, again, without actively engaging in any recreation activities (e.g., fishing, photography) involving these salmon. This sort of value is called a non-use or passive-use value and captures that value people have for resources for possible future use by themselves, future use by future generations, current use by others, or simply because they think it is the right or moral thing to do.

Predict the impacts quantitatively over the life of the project

A comprehensive classification of impacts and their associated costs and benefits is complicated by the extent to which direct impacts transfer across agents, markets and natural systems, and the degree to which this transfer is measurable. The future time path of changes to health, the economy, and the environment must be estimated in some way. This estimation may rely on an extensive review of existing scientific knowledge and data, or may rely on a new analysis.

As part of the restoration plan, the California Resources Agency is to prepare a Program Environmental Impact Report (PEIR) that will analyze the potential environmental impacts of the alternatives included in the Ecosystem Restoration Plan. For the restoration of the Salton Sea, a lengthy time horizon and complex interactions will certainly make the estimation of cause and effects difficult and costly. When constructing and evaluating the Draft PEIR, this cost must be weighed against the importance of accurate estimation, or the cost of making the wrong decision. It may indeed be impossible to directly measure some impacts. When this is the case, a proxy measurement must be constructed to account for the impacts.

Monetize (attach dollar values to) all impacts

Once all impacts have been identified, cataloged and estimated, their monetary value must be determined. In this way, benefits and costs can be compared in dollars. When the impacts occur through markets (such as costs associated with construction, or the benefits of created jobs), monetization is relatively straightforward. These values can be derived using the appropriate demand curve and estimated changes in market prices and quantities. The estimation of non-market (and especially non-use) values presents a challenging problem in measuring the full value of resources, but is facilitated by well-established valuation techniques, the most popular common of which are discussed below.

Discount benefits and costs and obtain present value

Many projects related to the environment will have costs and benefits that accrue over time. For restoration projects, it is often the case that costs are borne “up front”, or in the present, while benefits do not accrue until sometime in the future. Because dollars or resources consumed today are worth more than the same dollars or resources consumed in the future (due to peoples’ preferences to consume now rather than later), values that occur in different time periods need to be converted into a common period equivalent by “discounting” future values to their present value via a social discount rate.

The social discount rate, as noted in Pearce & Turner (1990), should reflect the rate at which society is willing to trade current dollars for future dollars, and depends on the degree of risk associated with the future payoff. Since there are a wide variety of opinions as to society’s aversion to risk, choice of this rate is a matter of much debate. Mathematically, lower discount rates make the present value of future dollars appear higher, and vice versa. Hence, higher discount rates weaken the case for projects with benefits that occur over long time horizons relative to up-front costs. With this in mind, using a predetermined rate removes the temptation to choose a discount rate in order to achieve a desired net benefits result. Indeed, many projects funded by the U.S. government use a real (inflation adjusted) discount rate of 7% (Boardman et al., 1996). However, because the discount rate can affect the outcome substantially, a range of discount rates and their corresponding net benefits should be analyzed and presented.

Once future costs and benefits for project or policy alternatives have been discounted, the present value of costs should be subtracted from the present value of benefits in order to arrive at the net present value (NPV) of each alternative. When deciding among competing alternatives, including the baseline, the project or policy with the highest NPV will yield the highest net gains to society and, thus, is considered the efficient choice.

Perform sensitivity analysis and make a recommendation

Even with the best available scientific information, most projects will involve some degree of uncertainty in predicting impacts, deriving their monetary value, or discounting future values. This uncertainty may be due to unknown parameters, lack of data, or lack of information about future environmental or economic conditions, which are often complex and difficult to predict. Such uncertainties exist with regard to the restoration alternatives for the Sea, including future annual inflows, salinity, habitat and wildlife impacts from construction, and the amount and nature of dust that will be created as the Sea's elevation drops over time. When some degree of certainty can be assigned, the most probable or plausible values of the uncertain parameters should be identified and reported as a "base case" scenario. Examination of a reasonable range of parameter values and probabilities around this base case acknowledges the uncertainty of the estimation and provides a means of examining the sensitivity of results to underlying assumptions. It is critical for the analyst to report on the robustness of the results to underlying assumptions so that policy makers can be fully informed. If net benefits remain consistent over a range of possible values, one can be more confident in the results. Within a reasonable range of uncertain parameter values, the alternative with the highest NPV should be recommended. With respect to the Salton Sea, a present value net benefits approach with sensitivity analysis would seem useful for evaluating the proposed restoration alternatives and their trade-offs.

Valuing Environmental Goods and Services

For most goods and services, the starting point for estimating value is the market price. Yet for many environmental and natural resource goods and services, no such market price exists. For goods such as clean air, biodiversity, endangered species, and wildlife habitat, rarely are there market transactions revealing the price and subsequently the value of these goods and services to society. Consequently, the value of these goods and services is not readily apparent to policy makers in charge of determining how these scarce and often unique resources are to be allocated. As an example of this problem, consider the decision of how to allocate an acre of land in, say, Sequoia National Forest. There is value associated with the timber that could be obtained from these giant trees. Yet, there also is value in preserving the forest in its present state for recreation activities such as hiking, camping, and photography today and in the future. There is value indirectly in the habitat these forests and trees provide for other wildlife resources we enjoy. There is value also in simply knowing that these resources exist for use by others, and possible future use by current and future generations. As such, we define the value of a resource that is not revealed through market transactions as its non-market value. Without knowledge these non-market values, benefit-cost analysis is limited in its usefulness in aiding policy makers on how to efficiently and equitably allocate these resources.

The objective of non-market valuation is to estimate the economic value of these environmental and natural resources to society. Quantification of the benefits gives these goods and services standing in benefit-cost analysis. In considering the benefits of preservation, the total value of the resource should be considered, where total value is defined as:

Total Economic Value = Use Value + Non-use Value.

Use value relates to the tangible use of the resource presently, and can include both consumptive use (e.g., *catch and keep* fishing) and non-consumptive use (e.g., photography, or *catch and release* fishing). Non-use value, as described in Kopp & Smith (1993: 340), is that "…component of the value of a natural resource that does not derive from the in situ consumption of the resource." There are four general categories for non-use values, including: *option value*—the value that people place on a good or service for future possible use; *altruistic value*—the value someone places on the preservation of a resource for use by others in the current generation; *bequest value*—the value someone places on the preservation of a resource for use by future generations; and *existence value*—the value one places on a resource for its mere existence, possibly for moral or ethical reasons.

In considering the non-market values associated with preservation of the Salton Sea, a variety of stakeholders come to mind. The Sea provides many non-market benefits to the State of California. Thousands of visitors frequent the Sea annually for bird watching, it has been the only Tilapia sports fishing area in the state, and other activities such as camping, boating, and swimming occur throughout the year. Indeed, the Salton Sea has been considered one of the most productive fisheries in the world (Cohn, 2000), especially during the years from 1960 to 2000. In 1987, there were nearly 2.6 million visits by recreators to the Salton Sea, making it a more popular destination than Yosemite National Park (CIC Research, 1989).

The Sea also provides non-market benefits to the nation as a whole. The Salton Sea is ranked as the second highest birding area in the nation. Indeed, 90% of the North American population of eared grebes, more than 80% of the entire western U.S. population of white pelicans, and nearly half of the U.S. population of Yuma clapper rails (an endangered subspecies) utilize this habitat. The Sea is one of two nesting areas in the western U.S. for gull-billed terns, a bird proposed for listing as a threatened species. From a fishery perspective, the Sea has supported eight species of fish, including the federally endangered desert pupfish.

Non-market Valuation Techniques

Three of the most popular methods for estimating non-market values for natural resources include the Travel Cost Method, the Random Utility Model, and the Contingent Valuation Method. The first two techniques are *revealed preference* methods—methods which examine decisions that individuals make regarding market goods that are used together with non-market goods to reveal the value of the non-market good. These methods require that a link be established between changes in the environmental resource and changes in the observed behavior of people. For instance, changes in water depth and salinity in the Salton Sea may result in fewer fish. Anglers may then move to another part of the Sea, move to a different fishing location, or take fewer fishing trips. In establishing this link, it is important to account for any other factors that may be causing behavior to change. With this information, a demand or marginal willingness to pay function can be estimated, which allows one to estimate the value of environmental resource changes. While revealed preferences methods allow for estimation of use values, they cannot be used to estimate non-use values. To elicit such values, *stated preference* methods, which ask people directly about the values they place on non-market goods, must be used. The most widely-used stated preference method is the Contingent Valuation Method.

Travel Cost Method

The travel cost method (TCM), one of the most widely used revealed preference valuation techniques, uses information on actual behavior to estimate a trip demand curve from which the value of the resource can be derived. The demand curve is estimated using visitation data, including travel costs and the number of trips taken by each individual to a particular site. Using distance traveled as a proxy for the price of a trip, and the number of trips as the quantity, individual or group demand curves can be estimated for a site. The net benefits of a particular site or the value of the resources within each site can then be estimated.

As noted in Loomis & Walsh (1997), the recreational benefits from a well done TCM analysis should be fairly accurate, partly as a result of over 45 years of investigating and improving upon this technique. This method has been used by both state and federal agencies to value a wide variety of non-market goods and services. For instance, the TCM was used by Beal (1995) to estimate the value of camping at Carnarvon National Park. Results suggested that the annual net present value for camping at this park alone was nearly $40 million. Other recent analyses include valuing hiking in National Forests in Colorado and Montana (Hesseln et al., 2004), canoeing in Canada (Hellerstein, 1991), hunting in California (Creel & Loomis, 1990), Chinook Salmon sport fishing in Alaska (Layman et al., 1996), and ecotourism and wildlife viewing in Costa Rica, and Kenya (Menkhaus & Lober, 1996; Navrud & Mungatana, 1994). This method could similarly be employed to value the flow of recreation services from the Salton Sea. Application would require a survey of recreationists who use the Sea. In addition to a host of demographic information, survey respondents would be queried about the frequency of their participation in recreation activities at the Sea.

Random Utility Model

While application of the TCM would provide useful information on the value of recreation services from the Sea in its current state, a variation of this method, the Random Utility Model (RUM), may be more applicable to valuing potential changes in the Sea under the various restoration alternatives. The RUM has been used in a variety of applications, most commonly freshwater and saltwater recreational fishing (Bockstael et al., 1987; Schuhmann & Schwabe, 2004). It has also been used to value a wide assortment of activities at unique recreation areas, such as hiking in the Grand Canyon or Yellowstone National Park, rafting in the Middle Fork of the Salmon River in Idaho, and ecotourism and wildlife viewing in Italy (Font, 2000). RUMs are commonly used to model the choice among a set of qualitatively different recreation sites. By estimating how the choice of alternative sites is dependent upon the characteristics of those sites, the RUM allows the researcher to value changes in the quality or characteristics of those sites.

Given that each restoration alternative is likely to result in a different level of ecosystem services (e.g. expected changes in length of shoreline, elevation, availability of bird habitat, or fish catch rates), which in turn will differentially impact the quality or quantity of recreational activities, the RUM would be a very appropriate method of estimation. Such an application would require identification of substitute sites for each recreation activity at the Sea, a catalog of current measures of quality at each site, measures of the expected changes in quality that would result from the restoration alternatives, and a survey of recreationists at each site. As the RUM relies on information gained from actual choice occasions, this survey could be conducted in-person at the alternative recreation sites. This analysis would provide a quantitative assessment of the likely impacts on recreation benefits prior to any restoration action, so that the net benefits of each alternative are more completely understood.

Contingent Valuation Method

The Contingent Valuation Method (CVM) is a well-accepted technique for valuing non-market goods, with far greater than 1600 CVM studies to date estimating non-market values in over 40 countries (Carson et al., 1994). The U.S. Department of Interior (DOI) has adopted CVM to measure non-market values associated with damages under CERCLA 1980; NOAA has endorsed the use of this method for damage assessment under the Oil Pollution Act of 1990; and it is recommended by the Water Resources Council (1979) for use in benefit-cost analysis.

The goal of CVM is to create a realistic, albeit hypothetical, market where peoples' values for a good are expressed. A CVM survey consists of four main elements. The first element is a description of the program the respondent is asked to value or vote upon. This element often involves a description of the baseline services with no action, and an improved level of services with some type of policy action. Identifying the conditions of the "no-action" alternative and other restoration options may require research by physical and biological scientists. The second element of the CVM is specifying a mechanism for eliciting value or choice. There are a variety of options for eliciting value, the most well-accepted being a referendum type question that asks each respondent to vote yes or no to a specified price or prices. A payment vehicle describing the manner in which the hypothetical payments are collected is the third element. Such vehicles have included higher taxes or utility bills, or a payment into a trust fund (Loomis et al., 2000). The fourth element consists of collecting information on respondent characteristics including socioeconomic data and environmental attitudes.

Because non-use values entail no actual observable use of a resource, the ability to measure non-use values reliably has been questioned (Hausman, 1993). To assess the reliability of CVM in measuring non-use values, NOAA convened a panel of prominent social scientists co-chaired by two Nobel Laureate economists. The panel concluded that if CVM practitioners follow a certain set of conditions, the results obtained from CVM are likely to be reliable (Arrow et al., 1993). Subsequent research has discussed issues associated with the conclusions of the NOAA panel, and provided additional procedures that ensure CVM reliability (Hanemann, 1994).

Examples of Benefits Estimation for Preserving the Salton Sea

To date, little has been done in terms of quantifying, in monetary terms, the benefits of preserving the Salton Sea. No studies were found that used the methods discussed above to estimate the possible benefits from the proposed restoration alternatives. This is unfortunate since such information can be extremely useful in informing policy makers of the relative attractiveness of one option over another and justifying, *ex ante* or *ex post*, a particular decision. Two studies that have attempted to estimate the value of the Salton Sea include CIC Research (1989) and the Inland Empire Economic Databank and Forecasting Center (IEEC, 1998); unfortunately, neither study estimates the non-market benefits of preservation.

CIC Research (1989), for instance, focused on estimating the expenditures of Salton Sea recreationists and, subsequently, the potential impact those expenditures might have on both the local and regional economy, often referred to as the *secondary market effect*. Based on responses from a telephone survey of Southern Californian residents and an intercept survey at the Salton Sea, approximately 154,600 households engaged in recreation at the Salton Sea in 1987 for a total of 2.6 million recreation days. Household expenditures that could be directly related to recreation at the Salton Sea amounted to $76 million, of which $53 million was spent directly in counties contiguous with the Salton Sea. Using regional and local economic multipliers, it was estimated that the $76 million in direct expenditures generated an additional $221 million in secondary market impacts. Unfortunately, the ability to use these impacts to measure the benefits of preserving the Salton Sea is tenuous since this study measures expenditures, not benefits. Hence, very little in terms of the value of preserving the Salton Sea can be gleaned from the CIC Research study with expenditure information alone.

Alternatively, the IEEC (1998) focused on the economic benefits of cleaning up the Salton Sea. IEEC categorized these benefits into how changes in Salton Sea water quality would affect (i) privately-held developable property within a one-half mile of the Salton Sea shore and (ii) public sector revenues generated from taxes on property values and economic activity in the area. In estimating the benefits to private property owners for changes in water quality, IEEC considered changes in property values that would likely accompany an increase in water quality using retail market values from other tourist and recreation markets in the Southwest. Added to these privately-held property values, they calculated the expected change in tax revenue that would accompany the changes in both property values and economic activity.

The combined present value benefits of increasing Sea water quality was estimated to be between $2.6 and $3.2 billion, with slightly over half accruing to private property owners and the rest generated from tax revenues. A serious problem with these estimates, from both a qualitative and quantitative perspective, is their treatment of tax flows. While they account for tax dollars earned, they do not account for tax dollars paid—symmetry should apply. Furthermore, tax generation is simply a transfer of wealth from one group to another. If the taxes are paid by agents outside the region, then local governments in the Salton Sea vicinity would experience an increase in tax revenues while governments elsewhere would experience a decrease. More problematic is their estimation of the value of preventing further degradation of the Sea. In particular, they assume that the benefits of prevention can be approximated by the costs of prevention with the justification that if society is observed incurring the cost, it must be that the benefits exceed these costs (IEEC, 1998: 13). Yet, politicians and government agents may make decisions regarding resources on criteria other than economic efficiency.

Neither CIC Research (1989) nor IEEC (1998) nor any other study to date directly estimates the non-market values from preserving the Salton Sea. In cases like this where a primary valuation study for the resource of concern is absent, economists sometimes rely on existing valuation studies for similar resources to obtain a somewhat less accurate but still potentially useful benefits estimate. The use of previous non-market valuation studies to inform current decisions is known as *benefits transfer* (Freeman, 2003; Rosenberger & Loomis, 2003).

K2 Economics (2007) recently conducted a simple benefits transfer study for the Salton Sea that relied primarily on estimated values for two similar natural resources in California: San Joaquin Valley (SJV) wetlands and the Mono Lake ecosystem. Citing several analyses of contingent valuation survey data for SJV wetlands, K2 Economics determined that a conservative estimate of the current annual value of 1,000 acres of SJV wetlands to the residents of California is approximately $50 million. Assuming wetlands at the Salton Sea provide services similar to those provided by wetlands in the SJV, and assuming people value these services similarly, K2 Economics argued that this estimate also can be applied to wetlands at the Salton Sea. Transferring this value to the wetland acreage associated with each of the eight restoration alternatives implies a current state-wide annual value of at least $600 million, yet more likely in the range of $1.9-$4.4 billion for preserving the Sea (K2 Economics, 2007).

K2 Economics also used results from multiple contingent valuation surveys for the Mono Lake ecosystem to develop a separate transferable estimate for the value of preserving the Sea to the residents of California. Making conservative assumptions about values expressed for restoration of Mono Lake, K2 Economics determined that the current state-wide annual value of preserving the Sea is around $1.5 billion and possibly higher. Again, this estimate relies on strong assumptions about similarities between both the services provided by Mono Lake and the Salton Sea as well as the populations receiving the benefits. It also involves a relatively large amount of uncertainty compared to a primary valuation study of the Sea. Regardless, after considering both the SJV and Mono Lake benefit transfer results, K2 Economics concluded that a conservative order-of-magnitude estimate of the non-market benefits provided to the residents of California from preserving the Sea would be in the range of $1-$5 billion annually.

Interestingly, the estimated construction costs of the eight restoration alternatives range from $2.3 to $5.9 billion (California Resources Agency, 2006), a large number indeed. Yet, if one were to take the results from K2 Economics (2007) as a conservative order-of-magnitude estimate, the benefits of preserving the Salton Sea to California residents alone would seem to pass the benefit-cost test (i.e., positive net benefits). Furthermore, consider the results of Loomis (2000) who, in evaluating six different resource preservation programs, finds that residents within the states where each resource is located hold only a fraction of the total national value. This suggests that from a national perspective, the $1-$5 billion range is a very conservative estimate of restoration benefits to residents of the U.S.; consequently, the net benefits of preserving the Salton Sea are large. Of course, until a more detail primary non-market valuation study is performed, comparison of the individual restoration alternatives from a net benefits perspective would not be very informative and accurate.

Conclusions

The Salton Sea is a natural asset that provides many ecosystem services that directly and indirectly impact the quality of life for people at the local, regional, state, and national level. Such services include boating, fishing, hiking, photography, bird watching, and habitat provision for an abundance of birds, including migratory and resident as well as endangered and threatened species. The viability of this ecosystem and its ability to continue to provide such services will be dependent on the engineering solutions devised for restoration, yet it will also be influenced by regional agricultural activities and the quantity and quality of the associated drainage water. Any additional impositions on agriculture will likely impact agricultural-related industries and activities and, subsequently, effect regional employment and income.

In consideration of these effects, this article has argued that a net benefits framework would be the most useful approach in which to evaluate and compare alternative restoration strategies. Relative to a cost-effectiveness or cost-minimizing approach, net benefits analysis can provide more accurate information regarding potential net returns associated with a particular restoration alternative and present a clearer picture of the magnitude and distribution of benefits and costs at the local, state, and national levels. Certainly, it would seem useful for the legislature to have information on both the potential returns that each restoration alternative provides as well as the magnitude of the resources society is being asked to forgo to provide those returns. If such returns and costs cannot be quantified and monetized, then at the very least an enumeration of the trade-offs associated with each restoration alternative should be provided to inform the discussion. In addition to a description of how the physical characteristics of the Sea will differ across the restoration alternatives, qualitative information on the differences that each alternative presents for recreation opportunities, air quality, wildlife preservation and other changes that society values should be provided. This enumeration exercise will help to identify what is missing, both qualitatively and quantitatively, in efforts to account for the full array of impacts of any particular alternative. This framework highlights the trade-offs associated with each alternative and exposes the limitations, thereby stimulating the need for additional scientific research to achieve better understanding.

Equally important, we have emphasized the fact that non-market goods, such as many of the ecosystem services provided by the Salton Sea, have been and should be part of any sound economic analysis involving habitat restoration. The recreational and preservation benefits derived from the natural resources of the Salton Sea will be directly dependent upon which restoration alternative is selected. These types of benefits have been given standing by state and federal legislation and regulatory mandates, and have been shown to be one of the most important arguments in determining the class and scope of preservation that should occur.

While no primary non-market valuation studies have been performed to estimate the value of preserving the Salton Sea, and thus an accurate comparison of the alternative restoration strategies is limited, other research has estimated the value of somewhat similar ecosystems and their services (e.g., Mono Lake or wetlands in the San Joaquin Valley). The results from these other studies seem to suggest that the benefits of preserving the Salton Sea far exceed the costs. This is not surprising considering the research of Loomis and White (1996), who perform a meta-analysis of valuation studies for rare, threatened, and endangered species. The authors find that even for the most costly endangered species preservation efforts, the benefits are likely to exceed the costs. Yet for the particular case at hand, to accurately compare the trade-offs associated with different restoration alternatives, a primary valuation study is necessary and should couched as one part, albeit a significant part, of a net benefits analysis.

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