Natural Resources Law Center
University of Colorado School of Law

ISSUES RAISED BY ECONOMIC DEFINITIONS OF SUSTAINABILITY

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Richard W. Wahl[1]

Can the modern industrialized world, whether or not we maintain anything like current rates of population growth, long sustain standards of living that place stress on our natural resources, and can we extend those standards of living to a large percentage of the world's population? Similar questions have captured our interest at least as far back as 1798 when Thomas Robert Malthus wrote his "Essay on the Principle of Population." In a more modern form, "sustainability" is a defining issue for the environmental movement and an increasing concern for many managers of resources, both global and local. Yet, like the concept of the "public interest," "sustainability" is often used in public discourse without precise definition. Indeed, it may be a term so malleable to the particular interests of those who mouth it that it should be defined with greater care.

Economists have attempted to provide very precise definitions of sustainability, albeit within the confines of particular economic models.[2] These models abstract from the myriad of transactions in an economy a few fundamental types of activities, such as production, consumption, savings, and the preservation of natural capital. The purpose of this paper is to discuss economic definitions of sustainability with the goal of providing some reference points in ongoing discussions for a Natural Resources Law Center project on Sustainability on the public lands, which is part of the Center's Western Lands Program. In that respect, it is meant to be a companion paper to one authored by Wilson Crumpacker, which discusses, among other topics, definitions of ecosystem management used by conservation biologists.

Undoubtedly the general concept of sustainability has its roots in biology: overcrowded or undernourished populations can crash precipitously or even suffer extinction. Perhaps it is worth saying at the outset that although there is some commonality in the

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[2]For an approachable overview of these models, see Toman, Michael, "Economics and 'Sustainability': Balancing Trade-offs and Imperatives," Land Economics, volume 70, no. 4, pp. 399-413 (1994).

economic and biological definitions of sustainability, there is also some tension between them. To mention one: biological definitions tend to focus on sustaining one particular species or ecosystem at levels above some threshold necessary for survival, where the threshold is high enough to take into account the risk inherent from variable influences on the ecosystem. As Dr. Crumpacker discusses, the conservation biologists' concept of ecosystem management is biocentric, focusing primarily on sustaining the integrity of natural ecosystems. On the other hand, economic theory takes values to be assigned by humankind, and economics tends to view all goods and services, whether provided by nature or humans, as substitutable in varying degrees for one another.

This leads economists to pose the following types of questions concerning substitutes, compensation, and tradeoffs. Are some ecosystems more valuable than others, either because they are rare or because of the species involved? Are there suitable substitute goods and services (or levels of economic compensation) adequate to allow at least some of the less valuable ecosystems to be disrupted to provide for other resource uses? These questions lead to some related distributional and ethical issues. To whom should such compensation be paid where federal lands are involved: the general taxpayer, or those who will most directly benefit from the ecosystem to be disturbed (which may not be easy to determine)? If ecosystems, undisturbed by humans, sometimes collapse, what should be the human role in either allowing or mitigating such collapses, whether natural or human-caused?

Before discussing various economic definitions of sustainability more directly, it is important to make clear that the general concepts of "goods and services" in economic theory encompass not only human-made goods and services, but also goods and services derived from nature and benefitting humans, including preservation for its own sake. "Goods" would include "nonrenewable" or "exhaustible" natural resources, such as coal and petroleum, and "renewable" natural resources, such as fisheries and timber stands, where the annual rate of natural growth depends upon characteristics of the natural population and its environment. "Nonconsumptive" recreational uses of natural resources, such as scenic viewing and preservation for its own sake, are probably best regarded not as "goods" or commodities, but as "services" of the natural environment, the level and quality of which services can be altered. In its purest form, the preservation of some portion of the global ecosystem, even if an individual never desires to visit it, has been labelled "existence" value. Note, however, that economics treats the value of all of these goods and services, even the desire for preservation, from a human perspective. This anthropocentric nature of value in economic theory has been criticized by some non-economists.

Economic Definitions

Efficient resource use and sustainability have been used in economics in two different ways. One might be referred to as the sustainability of "natural resources in the small" — the continued provision of a single resource, such as oil, natural gas, iron, or platinum. Single resource models are called "partial equilibrium" models. A second preoccupation of economists has been efficient or sustainable growth of an entire economy (say, for a country or for the globe). Such growth depends upon the entire stock of natural resources available to the economy, which we might label "natural resources in the large." These more encompassing models are called "general equilibrium" models. In principle, a general equilibrium model would incorporate the interdependent markets of all goods and services.

In practice, the models addressing sustainability of entire economies have usually been formulated using highly aggregated representations of the economy, such as the following.

Let

R = the stock of all renewable natural resources (natural capital), like fisheries and forests;

N = the stock of all nonrenewable natural resources, like oil, coal, or molybdenum;

K = the stock of human-made capital;

L = the size of the labor force; and

Q = the aggregate production of all goods and services.

Human-made capital is meant to include its various forms: physical capital (such as machinery, buildings, and highways), intellectual capital (such as knowledge and software), and human capital (skills and training).

Then, annual economic production can be formulated as a function of the annual use of natural capital, as well as the stock of human-made capital and the size of the labor force:

Q = f(use of R, use of N, K, L).

In any given time period (year), society can decide how much production should be allocated to current consumption (C) versus additions to human-made capital:

Q = [is divided into two parts] C + additions to K

The general level of human well-being, or "welfare" or "utility," is considered to be an increasing function of the overall level of aggregate consumption:[3]

U = U(C).

While increases in current consumption increase the current level of well-being, they threaten future well-being and future generations by reducing the potential store of human-made capital available for production. The potential for future production is also threatened to the extent that the present generation depletes natural capital, whether it be renewable or nonrenewable. Higher population levels can increase production due to a larger labor force, but also reduce resource stocks, whether human-made or natural, on a per-capita basis.

The hope of economists in elaborating these models is to capture the important elements of the sustainability question and to shed some light on what actions might be necessary to achieve sustainability. Two principal questions addressed by economists through such models are the following: 1) whether man's welfare or consumption levels, on a per-capita basis, can increase indefinitely into the future and under what conditions, or whether economies, faced with limited natural resources, must ultimately wind down, leaving our distant successors in a bleak and denuded world; and 2) whether sustainability of well-being can be achieved through market forces (e.g., some resources are voluntarily held to sell to the next generation), or whether government intervention in markets is necessary to achieve sustainability. As one might suspect, the answer to both questions is: "It depends."

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[3]In more detailed economic models of human activity, utility would be a function of the complete list of goods and services.

Discounting

In economic theory, discounting plays a prominent role in valuing future goods and services, but this concept is often misunderstood as shortchanging future generations. In mathematical terms, discounting means that the value of future goods and services is converted to "present worth" (today's dollars) by reducing their value by the interest rate for each year between the present and the year in which they occur. But this is simply the arithmetic for converting present investment into future returns and vice versa. If you invest $100 today and interest rates are generally around 6 percent, you expect to get $106 a year from now. Conversely, to measure the value of returns received a year from now, you would convert the $106 return to $100 present-worth; i.e., discount the future returns by 6 percent. According to this arithmetic, you would look favorably on any investment that you expect would return more than 6 percent per year (be it in monetary terms or real capital, such as land or equipment, for example), and you would regard unfavorably any investment that would return less than 6 percent annually.

In other words, the interest rate is a measure of the productivity of investment, and discounting to present-worth using the interest rate is a way of comparing returns from different time periods. If markets are working, then the interest rate is not only a general measure of the returns from investing money in stocks, bonds, or savings accounts, but also a measure of the "real productivity of capital." The real productivity of human-made capital might reveal itself as more efficient machinery or software or a better-trained workforce. Returns from natural capital would include the annual increase in the volume of wood in a timber stand and the annual increase in a fish population or a herd of cattle.

This concept of discounting appears to work appropriately as a tool for valuing future goods and services, provided all the goods and services under discussion are substitutable and reproducible. Without such conditions, however, discounting is problematic. For example, it might be reasonable to harvest a large percentage of the mature trees in a wilderness area if either 1) those who enjoyed the forest would be equally content with other goods and services (or with monetary compensation) as substitutes for the forest, or 2) the wilderness could be replaced. However, some of those who enjoyed visiting the wilderness or who derived satisfaction for its preservation may believe that there is no satisfactory substitute for it and no adequate technology in which to invest the profits from the timber sale in order to reproduce the wilderness. In other words, the irreversibility of some decisions and the lack of substitutability among some goods may mean that they should not enter into benefit-cost analysis with discounting with the same ease as other goods and services.

Note that what is really at issue here is not so much whether discounting is appropriate, but whether there are adequate substitutes or technologies for reproducing the resource that is to be exploited. In general, one could expect that lack of substitutes and reproducibility would be reflected in higher expected values for the resource, values which could be accommodated within the traditional benefit-cost framework. In practice, however, it is difficult to know how much future generations would be willing to pay for resources, such as wilderness, that may be subject to irreversible decisions in the present. And, as discussed below (the work of Howarth and Norgaard), there are other arguments that some resource preservation decisions should be removed from a benefit-cost framework.

Discounting has been used in another context in economics. Some models of economic growth (discussed below) discount the well-being, or utility levels, of future generations. This appears to be an entirely different matter — a step which may be both questionable and technically unnecessary. The fact that such models also incorporate human-made capital adequately captures the role of discounting in production. The use of discounting for utility levels in these models is roughly tied to the notion of a marginal rate of time preference — that individuals would show some preference for having a good or service available now, as opposed to a year from now. But, when translated into severe discounting for the well-being of generations far into the future, the notion seems austere, if not immoral. Why should we give less weight to future consumption of goods and services, compared to present goods and services, unless a small investment now can lead to more goods and services later? Indeed, other models of economic growth have been elaborated without the artifice of discounting future utility levels.

Economic Models

We place economic models dealing with economic growth and sustainability into several basic categories (see Table 1):

Table 1. Model Objectives and Definitions of Sustainability		
MODEL OBJECTIVES, OR DEFINITIONS OF SUSTAINABILITY	NATURAL RESOURCES IN THE SMALL INDIVIDUAL RESOURCES	NATURAL RESOURCES IN THE LARGE THE AGGREGATE RESOURCE BASE OF AN ECONOMY
Maximize present worth — discounted net benefits or utility	Neoclassical partial equilibrium (Hotelling, 1931)	Neoclassical growth models (Solow, Stiglitz, 1974; etc.)
Maximize minimum utility (maximin) — Rawls	N/A	Neoclassical growth models (Solow, 1974)
Nondeclining utility over time	N/A	Neoclassical growth models, overlapping generations models

Partial equilibrium (single-good), neoclassical models

As far back as 1931, Hotelling elaborated single-good models using the objective of maximizing the present worth of benefits, less costs (the standard benefit-cost criterion).[4] Hotelling showed that the resource allocation achieved through profit maximization by individual firms gave the same result as maximizing "social value," measured as benefits less costs. Stated in other terms, where property rights in the exhaustible resource are clearly established, market forces will lead to "efficient" utilization of an exhaustible resource. The price of the exhaustible resource rises over time, which rations its use.

In such models, whether the resource is exhausted in a finite time or lasts indefinitely depends upon a number of factors. Where resource extraction is limited by economic factors

[4]Hotelling, Harold. "The Economics of Exhaustible Resources," The Journal of Political Economy, volume 39, pp. 137-175 (1931).

(an increasing cost of extraction for poorer grade deposits) rather than a mere physical constraint, resource use may be sustainable indefinitely. The higher cost of poorer grade deposits and their increasing scarcity ration the resource through higher prices, with less and less of the resource used in succeeding time periods.

Many others have followed in Hotelling's footsteps, elaborating or extending his basic model. Among the findings of that work are the following. The extinction of stocks of natural reproducible resources is consistent with the maximization of present value if private rates of discount are high relative to the rate of generation of the resources — an unregulated fishery can be driven to extinction. This is clearly a conclusion that would be in direct conflict with any definition of sustainability that focussed on the preservation of particular natural resources, such as the conservation biologists' definition.

Others have elaborated in some detail other factors that operate to sustain production in the face of an exhaustible resource. Products made with the resource, such as metals, can be recycled. For some resources, there may be a substitute "backstop technology" with a nearly constant unit cost of production and using a widely available resource, such as desalting seawater, powering vehicles with hydrogen, or nuclear fusion. Such a backstop technology would come into widespread use when the price of the scarce resource rose to a level high enough to make the backstop technology economically attractive. A third factor mitigating scarcity is technological progress, the development of new production processes that allow the same goods or services to be produced using fewer natural resources (e.g., better engineered steel beams) or with a less expensive resource (fiber-optic cables for communication, instead of copper ones).

Neoclassical models of economic growth

Neoclassical models address the growth paths of entire economies using various objective functions, typically maximizing the present worth of discounted utility levels of future generations. Solow[5] and Stiglitz[6] each showed that constant standards of living are

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[5]Solow, Robert M. "Intergenerational Equity and Exhaustible Resources," The Review of Economic Studies: Symposium on the Economics of Exhaustible Resources, pp. 29-45 (1974).

possible in the presence of nonreproducible natural resources even in the absence of technological progress, provided only that capital and resources are "good" substitutes in production and that "society" makes sufficient investments in human-made capital to offset the declining stock of natural resources.

A simple example of this is the following. You can live in a lean-to and build a fire every day, consuming more of the available timber supply. Or you can build an enclosed cabin with a stone fireplace, after which you would use less wood to keep yourself warm. In other words, you can convert some of the natural resources (timber and stone) into human-made capital (the cabin), with the positive result of having to use fewer natural resources in the future to maintain the same level of comfort, or even to increase your comfort.

This is a very important result, one which bodes optimism for the future. However, under some circumstances in these models, society can exhaust all of its resources. Such circumstances arise when the rate of savings from current production is very low (there is little increase in human-made capital), or when the stock of natural resources is low relative to the current population. In other words, to paraphrase the often-cited language of Dusgupta and Heal, 'optimal growth paths can be efficient, but perfectly ghastly' for future generations.[7] At a regional level, you might burn the forest to keep warm until the forest is gone, or until you have to walk too far each day to get wood (one explanation offered for the Anasazi abandoning Mesa Verde). Extended to the global level, such exploitation is the environmentalists' nightmare.

The Rawlsian definition applied to the neoclassical models

Faced with the possibility of such dire consequences, some economists began searching for other objective functions that would assure sustainability. One such model was elaborated by Robert Solow in 1974, using an objective function fashioned after the work of philosopher John Rawls. Rawls held that society (in a single generation) should be organized so as to

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[6]Stiglitz, Joseph E. "Growth With Exhaustible Natural Resources: Efficient and Optimal Growth Paths," The Review of Economic Studies: Symposium on the Economics of Exhaustible Resources, pp. 123-137 (1974).

[7]Dasgupta, Partha and Geoffrey Heal. Economic Theory and Exhaustible Resources (Cambridge: Cambridge University Press, 1979).

maximize the position of the least advantaged. Solow translated this objective into the intertemporal one of maximizing the per-capita utility of the generation that was the least well off. Put in other terms, the goal is to maximize the minimum welfare (the so-called "maximin" strategy) or to provide for the "best worst-case." This is a very risk-averse strategy. As Solow elaborated, the Rawls criterion can be met, but it leads to somewhat unsatisfactory consequences. He showed that the maximin policy leads to equal consumption over all generations. If the initial capital stock is low, there will be no more accumulation of capital and the standard of living will be low forever. Put another way, under this definition of sustainability, all generations are held prisoner to the capital of the first. Most people's common sense would probably lead to a different plan for society: if the first generation has low capital, then it might well have the foresight and desire to sacrifice some current consumption to make the succeeding generations better off.

More recent formulations

These findings led to the search for still other more satisfactory definitions of desirable growth paths. One is that levels of utility should be nondeclining. This allows for some generations to be worse off than others, but each generation must leave an endowment of resources sufficient to assure that the next generation is at least as well off. There are many different formulations of models in this category, of which we will mention only a few for illustrative purposes.

Alex Mourmouras discusses an overlapping generations model in which production depends on human-made capital and a renewable natural resource (there is no exhaustible resource).[8] He finds that society can have increasing living standards, provided that each generation preserves for the future the stock of natural resources it inherits from the past. Growth in the standard of living takes place via accumulation of human-made capital. In this model, resource prices first rise, then the economy moves to a state where resource prices are constant and the interest rate is equal to the natural rate of reproduction. This is another very

[8] Mourmouras, Alex. "Conservationist Government Policies and Intergenerational Equity In an Overlapping Generations Model with Renewable Resources," Journal of Public Economics, volume 51, pp. 249-268 (1993).

optimistic result, analogous to the findings of Hotelling, Solow, and Stiglitz in other types of models.

However, Mourmouras finds that there are also conditions under which sustainability is not possible (i.e., in which living standards decline, along with the stocks of human-made capital and natural resources). Such conditions involve a combination of (a) low rates of regeneration of natural resources relative to human population growth, and (b) low levels of saving caused by high rates of time preference and low labor intensity in production. Nevertheless, in these dire situations, he finds that it is possible to achieve sustainable growth in the standard of living by (a) relying on market forces to facilitate accumulation of human-made capital, and (b) relying on government conservationist policies to guarantee that the stock of natural capital is maintained intact.

These observations are useful, and the warning that government intervention in markets for natural resources may be necessary in some cases is noteworthy. However, one aspect of Mourmouras' formulation begs an important question that modern humankind faces daily: can we really afford to maintain our entire stock of renewable natural capital intact? For all practical purposes, both to accommodate additional population and to access our nonrenewable mineral and fuel resources, we must inevitably trespass on some of our renewable resource lands (forests, agricultural lands, etc.).

Also worth mentioning is work by John Hartwick. Going back to Hotelling, models with exhaustible resources have found that the price of the resource will rise above the costs of extracting and producing the resource (the price rise is the vehicle for allocating the scarce resource). The difference between the market price and the cost of production is termed the "resource rent," which might loosely be termed the profit from the exhaustible resource. For a model with a constant population and in which capital does not depreciate, Hartwick found that society can maintain constant per capita consumption (the equivalent of the Rawls objective function as used by Solow) if it invests all of the economic rents from exploitation of the exhaustible resource in augmenting human-made capital.[9] Over time, natural capital declines and is, in effect, transformed into human-made capital.

Observations on these models

Before moving to a related topic, let me offer some observations on these models. (1) Since these models use per capita consumption or "the representative citizen from each time period," they are not intended to address inequities in the distribution of resources among members within a single generation. (2) In these models, consumers derive satisfaction from consumption only, not directly from the stock of resources. Such a formulation appears to miss an important aspect of our dilemma. We enjoy direct consumption of the very forests and rivers (scenic views) that also provide us timber resources and hydropower, which suggests that resource stocks should enter directly into the utility function, as well as consumption (e.g., U = U(C, R, and possibly N). (3) As previously mentioned, Mourmouras' conclusion that we keep the stock of renewable natural resources intact is unsatisfying: our real situation is that we must use up some of our environment in order to use exhaustible natural resources. It would be interesting to see some additional attention paid to aggregate models that took into account these latter two points.

Howarth and Norgaard's critique

A more generalized critique that can be applied to these modelling approaches comes from a different direction. Howarth and Norgaard acknowledge the Hotelling results, but say that his findings don't really tell us much.[10] While Hotelling's findings provide us with production rules that guarantee efficiency (i.e., maximizing the present worth of benefits, less costs), they overlook potential improvements in welfare achievable through the reassignment of property rights, or levels of consumption, across generations.

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[9]Hartwick, John M. "Intergenerational Equity and the Investing of Rents from Exhaustible Resources," 67 The American Economic Review, 972-974 (1977).

[10]Howarth, Richard B. and Richard B. Norgaard. "Intergenerational Resource Rights, Efficiency, and Social Optimality," Land Economics, volume 66, pp. 1-11 (1990).

This point is not new in economics. The analogous observation applying to the distribution of resources among market participants within a single generation, rather than the distribution of resources among different generations, is well known: namely, that a market equilibrium depends upon the initial distribution of resources. For example, suppose that there is a world with ten nations, with only one holding the entire stock of valuable petroleum. Then, all nations can buy oil with labor (and any goods they produce with their other resources), but only one nation has the valuable petroleum asset available for trade. If oil is valuable in relation to most other commodities, then the distribution of wealth among nations, even after market transactions, might be quite unequal.

The intergenerational analog is a world in which the present generation "owns" and knows the location of most all oil or related energy reserves. Through the expected prices of oil in the future, future generations can "bid" for that oil with the expected value of their labor and other goods and services they produce, as well as with the bequests of wealth and capital from the present generation. However, the situation is asymmetrical in that the future generations cannot bring new oil to the market. Howarth and Norgaard's solution for achieving intergenerational equity is to specify the resource endowment of each generation. A redistribution of resource endowments across generations could clearly lead to a different outcome than if all of the resources are "given to" the current generation, or at least subject to current management goals.

Howarth and Norgaard's observations may not be of much practical help. Who is to decide what the proper intergenerational endowments should be? Are we to rely on imperfect social decisions and a Congress beset with the need to make political compromises? However, Howarth and Norgaard's observations, though subtle and not novel (at least to economists), are powerful. 1) They note that the Hotelling results have often been interpreted to mean that setting aside more of a resource than is done by competitive markets would result in reduced social welfare. Their writing is a good reminder that this is not necessarily true. 2) Another consequence of Howarth and Norgaard's observations is that it is legitimate for our generation to attempt to make appropriate endowments for future ones. Clearly, we could interpret some national statutes and policies as having the goal of making just such resource-specific endowments, such as the Forest Reserve Act of the last century; the

Antiquities Act and the establishment of national parks in the early 1900's; and more recently, the Wilderness Act, the Endangered Species Act, and the Wild and Scenic Rivers Act.

These statutes, or, more generally, the goal of preserving specific natural resources or natural populations or ecosystems, also harken back to the conservation biologists' definition of sustainability. Howarth and Norgaard's work can be seen as providing some legitimacy, within economic theory, to resource-specific conservation, at least if there are widely held beliefs, or societal decisions, that such resource-specific preservation be undertaken.

Failures to Sustain

Before making some concluding points about what role economics might have in achieving sustainability, perhaps it is worth discussing briefly some examples of the lack of sustainability. It is often the case that society as a whole, or certain interest groups within society, expresses a general concern on the basis of some specific perceived ill. If this is the case with sustainability, then perhaps we are better off trying to address those specific ills rather than grappling with the seemingly intractable problem of suitably defining sustainability in general terms.

Some lack of sustainability may be due to conventional market failures

Almost anyone can think of some example of a resource that has not been sustained or maintained in the manner he or she feels it should be — whether this be the changed neighborhood of one's childhood, some nearby open space that has become subdivided or commercialized, an overused grazing allotment, or overrun sections of a national park. All of these fit into the category of sustainability of "resources in the small" — resource-specific preservation.

The desires of those seeking preservation of some of these resources may have to be fit into Howarth and Norgaard's notion of making specific endowments to future generations, but the lack of sustainability in many cases may be traceable to classical "market failures." Citizens may have a willingness to pay in the current generation to preserve open space, and many communities do. However, the willingness to pay may not be properly represented in the political process. Overuse of grazing allotments may result from one of many factors: 1) below-market fees for grazing on the public lands; 2) regulation that is inadequate to protect other affected uses, such as the value of riparian habitat for recreational fishing; or 3) the problem of the commons, where allotments are not suitably allocated. Crowding in national parks may be traced to low charges for use of the parks and inadequate limitations on using certain park resources. In other words, one can postulate remedies to at least some problems of perceived unsustainability through conventional economic prescriptions for treating common property resources, externalities, public goods, and underpriced or nonpriced resources.

Some values simply may not be sustainable

Even if we rationalized our system of charging for natural resources by using those conventional economic prescriptions and adequately taking into account the multiple users of the public lands, we might still find that some resources or services cannot be sustained. Now that hikers can be rescued by well-organized search teams if they are overcome by the elements and have at their disposal topographic maps to plan and guide their trips, as well as altimeters and modern lightweight equipment, can we really recreate the sense of wilderness felt by the early explorers of the West? Certainly the unfettered lifestyle of the early rancher in the West has not been sustained: the mountain rancher who relies on public and private lands must now deal with federal grazing regulations and the demands of other users of the public lands. The mixed sensations of freedom, awe, and terror that must have been experienced by many early settlers of the West may simply be no longer attainable, regardless of the romance attached to that period.

Sustainability can be enhanced by limiting population growth

Most all of these examples of unsustainability can also be linked to increased competition for resources, competition which increases as the result of population growth. Conversely, if we slowed or reversed population growth, many of the resource conflicts, though not all of them, would lessen. And, of course, population growth factors directly into potential problems of global sustainability, such as climate change. Economic models of sustainability also highlight the central nature of population levels: it is more difficult to sustain per-capita levels of consumption with lower per-capita endowments of exhaustible and natural resources. If we are serious about sustainability, whether for resources in the large or the small, then we need to consider means to limit population growth. Although population policy may seem to some to be only remotely linked to sustainability on the federal lands, the two issues are intimately intertwined.

How Can Economics Be Useful With Respect to Sustainability on the Federal Lands?

Economics provides some insight into defining sustainability on the federal lands in a useful way, as well as insight into how economic incentives may help achieve such sustainability.

What resources should be sustained?

In terms of deciding what resources to sustain, it seems clear that although sustainability on the federal lands may enhance global sustainability, it should not be equated with sustainability of natural resources in the large. Man's survivability on the planet will be decided by resource management on a scale larger than the federal estate. As a result, the goals for sustainability on the federal lands can best be viewed as societal decisions about which resources (in the small) should be preserved for future generations. As noted, there is substantial theoretical justification for setting aside particular resources for future generations.

Economics, taking values as given, does not itself provide guidance as to what to set aside or how much. The process for making these decisions can be regarded as either inherently political or the result of some amalgam of individual preferences. Willingness to pay studies (e.g., based upon observed behavior or willingness-to-pay surveys) can also provide some indication of this generation's willingness to pay for setting aside resources.

Given the range of substitutes for many resources, the process of establishing goals for sustainability on federal lands should carefully weigh whether there is adequate rationale for applying the notion of sustainability to common resources (such as groundwater) or to each of many separate animal populations or ecosystems (e.g., within each ranger district, forest, or region). Applying the concept of sustainability on too small a scale is likely to weaken its power considerably.

What does "sustaining" the resources mean?

Once decisions are made as to which resources to sustain, federal resource boundaries need not be a primary criterion; some part of the resource to be sustained may lie outside the federal boundary. As a result, substitute resources from private lands should be part of those considered for sustaining, achieved through compensation and outright purchase, by the acquisition of conservation easements, by cooperative efforts, or by regulation of the resource on private lands. The fraction of the resource within the public land boundaries may be easier to control, but ignoring the potential for including resource efforts on private lands may lead to ineffective and costly policies.

In spite of attempts to define sustainability precisely (e.g., in terms of a maximin criterion or nondeclining levels of well-being), it would appear to be a reasonable policy to allow a short-term decline of resource stocks or services if doing so can increase resource use later. One can think of numerous examples where such a strategy is already used, such as closing trails to allow for revegetation or withdrawing some members of species for regeneration in captivity.

Economic/regulatory incentives for sustainability

Common-property aspects of resource uses on the federal lands are likely to continue to pose enforcement and regulatory problems, creating significant challenges for achieving sustainability. As a result, we should consider more novel use of economic incentives, such as the following:

- Grazing allotments should be fully marketable, including purchase by environmental groups and departments of natural resources desiring to further limit grazing use.

- Entry fees to parks and campgrounds should be raised closer to market value to limit congestion, and these fees should at least cover the cost of providing these services.

- More effective means of prohibiting overuse of backcountry and wilderness sites should be explored. These might include more widespread use of required hiking permits, coupled with heavy fines for noncompliance. Since there are many entry pathways into most federal lands, perhaps some means of electronic monitoring should be used.
- Undoubtedly, one of the primary benefits received from the public lands is the scenic view afforded from motorways. Perhaps some means should be devised to charge those who receive this benefit — e.g., charging automobiles from outside the area for using the roadways by automatically monitoring license plates and assessing charges.
- The robbing of antiquities from archaeological sites continues to plague the public lands. Perhaps there should be a national registry for all such antiquities, coupled with a requirement that they carry a coded sticker.

Some of these proposals may strike the reader as smacking of "big brother" government. On the other hand, in an age when nearly all products have bar codes and when we are subject to video surveillance in stores and many people are connected by beepers and cellular phones, it seems foolhardy to ignore the possibilities afforded by current technologies when confronting resource management issues.

Conclusions

Economic definitions of sustainability may be both too broad and too narrow for the challenges presented by sustainability on the public lands. On the one hand, sustaining resources on the public lands, although it may enhance global sustainability, should not be equated with it. Formal economic definitions of sustainability, such as providing nondeclining levels of well-being, may not be adequate either. Citizens may well be willing to sacrifice some current resource use if it will enhance the conditions of their offspring; just how much does not appear amenable to mathematical specification. It is comforting that providing specific resource endowments for future generations is consistent with economic theory. However, this observation doesn't provide specific economic guidance to those faced with resource preservation decisions. We are likely to have to continue to grope our way toward deciding, as a society, what resources to sustain.

What is clear is that economic incentives could play a greater role in achieving sustainability, including the elimination of traditional market failures that act to deplete resources. Such measures would include eliminating natural resource subsidies, raising recreational fees and other charges for public resources to market value, and creating markets in commodity resources (e.g., grazing permits). Additional means that should receive further discussion include requiring permits for backcountry use and providing adequate enforcement, finding ways of charging for scenic viewing, and protecting antiquities through a requirement that they be registered. Curbing population growth, as well as rationing public resource use through fees and other means, must be a necessary component of policies to sustain the resources on our public lands. We must also face the fact that some additional changes are in store for our relation to the public lands as an inevitable consequence of past population growth and conversion of the West from a wilderness to a land that is largely settled.