Southwest Fisheries Center Administrative Report H-84-14

THE BENEFITS OF PRESERVING ENDANGERED SPECIES: WITH SPECIAL ATTENTION TO THE HUMPBACK WHALE

Robert O. Mendelsohn
School of Forestry and Environmental Studies
Yale University, New Haven, CN 06520

SEPTEMBER 1984

[NOT FOR PUBLICATION]

PREFACE

This report was prepared by Dr. Robert O. Mendelsohn during a month's fellowship at the Southwest Fisheries Center Honolulu Laboratory. The terms of the fellowship were to provide a University faculty member with the freedom to explore the nature of "existence values for marine mammal resources." In particular, we were looking for an analytical review of the economic literature on existence valuation and a conceptual discussion of evaluating or measuring the nonmarket value of endangered species such as the humpback whale or the Hawaiian monk seal.

Mendelsohn's work emphasizes the difficulty in separating nonuse aspects of a species' value from its direct and indirect use values. Mendelsohn takes a critical approach to most attempts to measure existence values for endangered species and natural resources. He further argues that measurement of use value must be sensitive to caveats concerning the type of use envisaged. Mendelsohn also takes a critical view toward non-utilitarian conceptions of value as applied to endangered species.

I believe this report provides the basis for developing more rigorous criteria for evaluating the possibility of measuring the benefits for preserving endangered marine mammals. Although quantitative comparison of dollar values in terms of costs and benefits from protection programs is not the only yardstick for evaluating preservation programs, it provides useful information for the public, user groups, and decision makers. A number of areas for practical application of the criteria suggested by this report exists within the field of marine mammal protection. A number of economists within the National Marine Fisheries Service look forward to further research in this area.

The Southwest Fisheries Center's economics fellowship program emphasizes the academic freedom of its participating scholars. As such, the report has received minimal editing although Dr. Mendelsohn did receive written comments from Center reviewers which he was free to incorporate or reject as he saw fit. Because the report was prepared by an independent faculty fellow, its statements, findings, conclusions, and recommendations are those of Dr. Mendelsohn and do not necessarily reflect the view of the National Marine Fisheries Service.

Samuel G. Pooley
Industry Economist
Honolulu Laboratory
September 11, 1984

ABSTRACT

This paper reviews and critiques the various benefits allegedly generated by endangered species. Although total benefits may be substantial, many of these separate benefits appear to be redundant and some are probably near zero. The most significant benefit of endangered species appears to be nonconsumptive use. Several suggestions are given about how to empirically measure the benefits of endangered marine mammals in the Hawaiian Islands.

INTRODUCTION

This paper is concerned with measuring the benefits of endangered species in general and the humpback whale and monk seal in particular. Although there are virtually no quantitative estimates of the value of any species anywhere (with the possible exception of the whooping crane--see Stoll and Johnson 1984), economists have pondered the potential value of endangered species for about two decades. The benefits of preserving endangered species fall into one of two categories. The most prevalent source arises from a utilitarian perspective--the species may be helpful to man either directly or indirectly. The alternative perspective considers a more altruistic view--that all species should be given the right to exist independently of any usefulness to man himself.

There are many potential ways a species could be beneficial to mankind. (1) There is user value from direct interactions between man and the species. Whether for consumptive activities such as fishing and hunting or nonconsumptive uses such as birdwatching, hiking, or photography, man clearly obtains pleasure, enjoys, and would therefore be willing to pay for close contact with individual species. (2) In addition to direct use, it is possible there are several indirect mechanisms through which the species is helpful to man. For example, the species may control a pest or may be an important link in the food chain for another species man considers valuable. (3) The species may also provide secondary benefits through a communication medium. A wildlife movie, book, or lecture can become a link between the resource and the public. Even without direct contact, the public through this medium can enjoy the species. (4) Some economists argue that some individuals obtain pleasure just from the existence of the species. (5) Other economists argue people obtain pleasure from the knowledge that species will be preserved for future generations--a bequest value. (6) Many naturalists argue that endangered species have scientific value as potential sources of new information about genetics, medicine, and ecosystems.

The considerable uncertainty about the long-term benefits of a species coupled with the irreversibility of extinction has led to yet other values. (7) Wild species have long been a source of genetic and chemical material. A potential value of any species is consequently chemical mining--the extraction of rare biochemicals directly from the plant or animal. (8) Quasi-option value is the benefit of waiting to make an irreversible decision until more information is available. One reason to preserve species is that their destruction is irreversible and may quickly be regretted. (9) Option value has been labeled as the premium people are willing to pay to keep the chance of having a species maintained given there is uncertainty. Each of these nine potential utilitarian values will be discussed in more detail in the forthcoming sections.

Each of the utilitarian benefits can be discussed in terms of annual benefits. If the species survives, it produces a stream of annual benefits from now far into the future. The total value of this stream is the present discounted value of all future benefits. Because this intertemporal evaluation is consistent across all measures (with the possible exception of quasi-option value and bequest value), the intertemporal quality of most of the benefits is ignored in the following discussions.

Some individuals question whether it is appropriate to judge the value of a species in terms of its usefulness to man. For example, Stone (1972) argues that perhaps nature should be given certain rights of existence. Alternatively, one could extend Rawls' (1971) discussion of income distribution across man to all of nature. Suppose we did not know which of the 30,000 vertebrate species we would be born into (the veil of ignorance), and we were asked how many species should be preserved. If we wanted to minimize our worst outcome (extinction), we would vote to keep all species. Existence would then be an inalienable right which could not be purchased away.

In the remainder of the paper, I argue that <u>direct and indirect use</u> are the principal reasons to maintain an endangered species. The remaining values either are reflections of direct use, and so are already captured (measured), or are too small to be of any consequence. I further argue that although one could endow each species with an inalienable right to exist, a sound philosophical argument can be made for considering the benefits and costs of each species' existence. Since the benefits of keeping a species will rarely be infinite, measurement of these benefits could be quite helpful for making better decisions about how best to allocate our preservation efforts across species.

For organizational convenience, a section is devoted to each of the nine utilitarian sources of benefits arranged in Table 1. Another section is devoted to the philosophical foundation of the right to exist. For each source of benefits, the empirical and theoretical literature on the subject is critically reviewed and preferred methods of measurement for the humpback whale and monk seal are suggested when appropriate.

It should be understood that the focus of this analysis is on the benefits of preserving individual species with dangerously low populations. Although the benefits of protecting wild populations which are not endangered are related to the benefits discussed here, some of the arguments and thus conclusions do not apply to abundant populations.

DIRECT USE

Direct use is the least controversial and most easily measured value of wildlife. There are two types of direct use--consumptive and nonconsumptive. In general, hunting, trapping, and fishing would be consumptive uses of wildlife because the participants use up the resource through their activity. Hiking, birdwatching, whale watching, and photography, in contrast, are generally nonconsumptive uses because the interaction need not harm or reduce the target population. In practice of course, these distinctions may haze as fishermen could release their catch while photographers so harass an animal that it perishes. These fine points aside, there is an important distinction between consumptive and nonconsumptive benefits. For species which are few in number, consumptive use could quickly

Table 1.--Preservation benefits of endangered species.

<u>Use values</u>

- Recreation
  - <u>Direct</u>
    - Consumptive
    - Nonconsumptive
  - <u>Secondary</u>
  - <u>Bequest</u>
- Nonrecreation
  - <u>Mining</u>
    - Chemicals
    - Genetic material
  - <u>Experiments</u>
    - Medical
    - Ecological
    - Biological

<u>Nonuse values</u>

- Indirect
  - <u>Elimination of pests</u>
  - <u>Enhancement of desired species</u>
- Risk
  - <u>Option value</u>
  - <u>Quasi-option value</u>
- Existence

---

lead to extinction as the population falls below a critical minimum (Bachmura 1971). Thus, endangered species are not suited to provide current consumptive benefits. More likely, the potential consumptive benefits of an endangered species are the discounted values of consuming the species sometime in the future when its population is at a healthy number. Thus, many species who have always had a limited habitat (population), or whose habitat has been acquired by other users, will have no consumptive direct use because they will probably never have a sufficiently large population to support taking. The Hawaiian monk seal, for example, limited to a few remote uninhabited islands of the Northwestern Hawaiian Islands, would likely fall in this category. In contrast, the humpback whale if it can recover like the sperm and gray whales have, may indeed provide consumptive use again in the future. Except in unusual circumstances where man has mismanaged a species terribly, the forces which drove a population near to extinction also limit the species potential for consumptive use. Thus, the humpback whale may sometime be hunted again, but because of its low reproductive rate such hunting could not be widespread. Most endangered species consequently will have low consumptive direct use benefits.

Several authors have discussed the conditions where upon an unregulated renewable resource could be driven to extinction. Unfortunately with common property resources such as a fishery, users tend to undervalue the common resource. Instead of maintaining the resource wisely over time, the common access users acting on individual but not communal interest deplete the stock. If unregulated, the fisheries tend to be driven to a point where minimal harvestable resources remain. Depending upon the cost of harvesting small populations, the fishery can be driven to extinction (Clark 1973; Cropper et al. 1979; Sinn 1982). Another extension of this renewable resource literature includes a discussion of how preservation value could enter the standard fishing model. Plourde (1975), Miller (1978, 1981), Miller and Menz (1979), and Porter (1982) model preservation value as being a value of the stock itself. The larger the value of the stock, the greater is the difference between the private returns to harvest and the social return. Although this literature is not directly pertinent to measuring preservation value, it does demonstrate that market mechanisms may lead to extinction even when preservation values are high enough to justify keeping the species alive.

In contrast, small populations of animals at least potentially could support relatively high quantities of nonconsumptive use. Thousands of people aboard large cruise vessels get the pleasure of viewing whales in Glacier Bay when there may be only a few whales in the whole area. A similar phenomenon with smaller tourist boats occurs off the coasts of Maui, Hawaii, and California. Clearly individuals are willing to pay substantial fees just to be able to view the animals at closer range.

The activities of naturalists who spend a large fraction of their time as volunteers or lower paid professionals observing wildlife is another example of nonconsumptive use. Clearly, these individuals are receiving substantial pleasure from their intimate contact with endangered species. Given the sizable expense and inconvenience endured by these dedicated researchers, the value of the species just to these individuals alone is clearly substantial.

Which species are likely to have large direct use benefits? Are all species of equal value? Although empirical evidence on this issue is limited, the answer is probably no--people distinctly value some species more than others. The eagle, elk, and whale are of distinct value because of their size, complexity, and grace. They are also of great value because they are distinct from other species in ways of interest to man.

The taxonomist's definition of a species is any distinct group which does not interbreed with another group. The taxonomist's observed distinctions across groups, however, may often not be shared by users. Thus, for example, there may be 15 species of wild grass with subtly different characteristics. The destruction of 5 of these 15 grasses may go unobserved to most people. On the other hand, the demise of the bald eagle or humpback whale would be a great loss to many users. Uniqueness is not an all or nothing attribute. Every species by definition is different, but they are not necessarily different in important ways. Users probably care about very unique species but their definition of uniqueness is much broader than the taxonomist's. Only a fraction of the taxonomist's species truly qualify as unique. What is relevant--seals in Hawaii, Hawaiian monk seals, or all seals of a particular type regardless of location?

Three techniques have been used to value recreational direct use: the hedonic travel cost, market demand, and the contingent valuation method. The hedonic travel cost method (Brown and Mendelsohn in press) learns from the choices users make about which sites to visit, i.e., the value they place on the characteristics of sites. Thus, if there were a series of boat trips one could take on which some saw whales and some did not, it would be possible to estimate the individual value of the whales as one of the trip's characteristics. Unfortunately, for humpback whales in Hawaii, the limited choices of destinations in which to encounter the whales would make it difficult to separate the value of the whales from other characteristics of these areas.

Because a great deal of whale watching is done on private boats which charge fees, it is possible to use a market demand approach to estimate the user value of the whales. The marginal whale watching trip is presumably worth the fee the user pays for the last trip (otherwise it would not be the last trip). However, each trip also requires substantial resources in boat capital, fuel, and labor (crew). Assuming whale watching trips are generated competitively, the marginal cost of these services is the price paid for the last trip. Thus, the last trip provides zero net benefits (the benefits equal the cost of access). The value of the whales lies in the value of the inframarginal trips (the trips before the last trip). It is, therefore, necessary to estimate the demand for whale trips. This demand function can only be revealed if there is observed price variation leaving one of two possibilities of attack: a cross-section study across operators or a time series analysis. The relationship of interest in either case is how the number of whale watching trips (person trips) is affected by the price per person trip. The consumer surplus, the area under this demand curve but over the current market price, P_0 would reflect the annual nonconsumptive use value of the resource (Fig. 1).

A third possible approach to measuring direct nonconsumptive use is to ask users what they are willing to pay to obtain access to the whale. The accuracy of the response depends upon the quality of the question because it is necessary that the respondent understand the hypothetical question being posed. Stoll and Johnson (1984) have applied this technique in Texas to value whooping cranes at Aransas National Wildlife Refuge. They found visitors (i.e., users) were willing to pay $4.47 per year to visit the

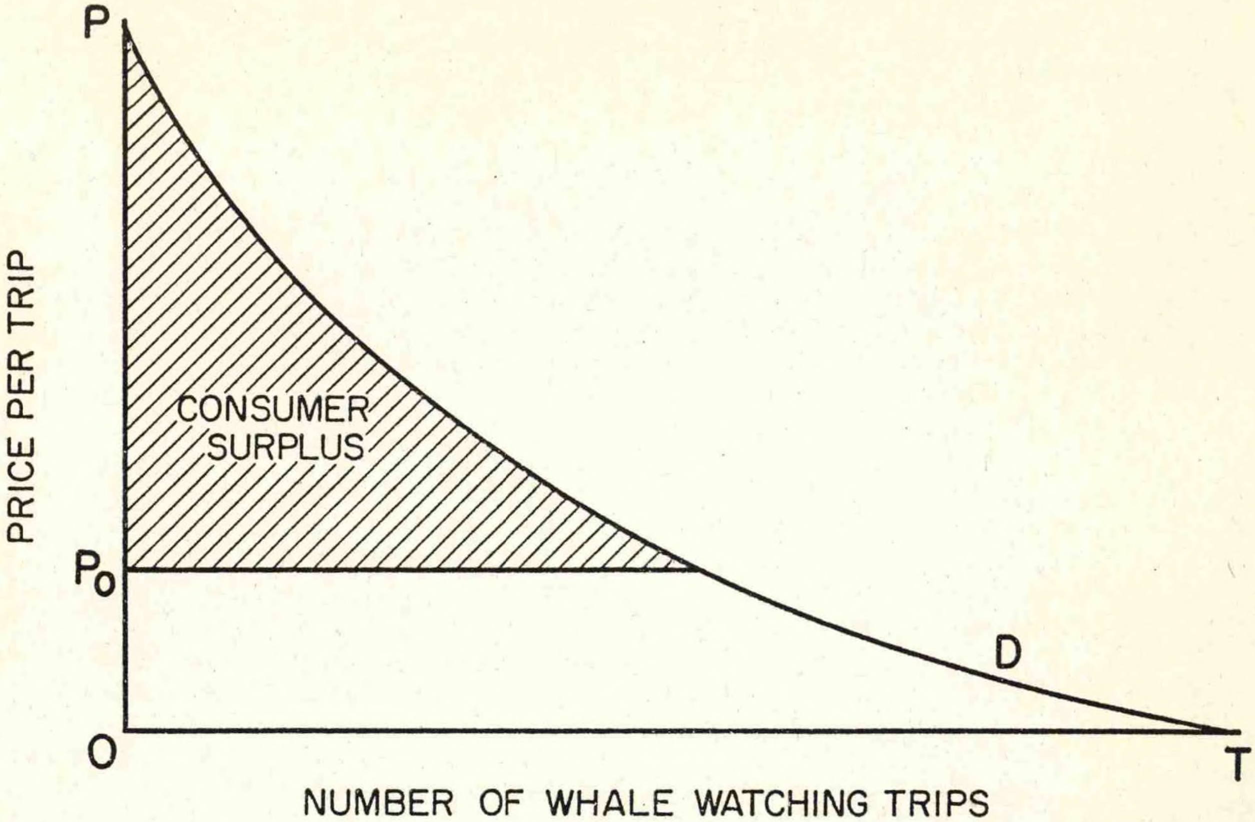

Figure 1.--The demand for whale watching trips.

refuge with whooping cranes present but only $3.07 without whooping cranes. The difference, $1.40, is presumably the value of the rare bird. Given the sample size, this difference is statistically significant at the 5% level. Multiplying by the 60,000-100,000 people per year who visit the refuge suggests the whooping crane provides $84,000-$140,000 annual benefits to Aransas National Wildlife Refuge users alone. Given the migratory nature of the bird, the total value to all "users" including people in other locations is presumably an even larger number.

Clearly the contingent valuation approach to measuring user value could be applied to value endangered species in the Hawaiian Islands. For example, all visitors to Maui and especially those purchasing the whale watching trips could be sampled to evaluate the humpback whale. In particular, it would be interesting to know what people would be willing to pay for an increased probability of seeing a whale, how much more they would pay to see the whale closer, and how much more they might pay to see more than one whale. Given that few visitors have seen a whale before, it might also be interesting to test whether their attitudes before sightings were similar to their responses after experiencing the whale. Finally, it might be interesting to query whether they perceived that the whale was threatened or harassed by their own approach, and if it was in fact being harmed whether they would prefer such access eliminated.

INDIRECT USE

It is entirely possible that in addition to the direct value of contact between man and a particular animal, the animal provides additional benefits (or costs) through its impact on the ecosystem. For example, seals may eat abalone or lobsters and thereby reduce the population of this desired delicacy. In this case, the seal would be generating an indirect cost measured through another species. On the other side of the ledger, an animal may control a pest. For example, mosquitofish, Gambusia, catch mosquito larvae and control that pest effectively in local areas. Alternatively, fish may be an important source of food for valuable wild or game animals higher in the food chain.

Indirect use captures the relevance of the species to an ecosystem. Because ecosystems involve complex, interrelated balances, the elimination of a species can affect the remaining populations. Indirect use is consequently an important component of the total benefits of many species.

The question we must face, however, is not whether indirect use could ever be important, but rather whether it is likely to be an important component of endangered species. By definition, endangered species populations are few in number and so generally are unable to have a significant impact on the environment. For example, whether or not a population of a hundred small fishes were wiped out is unlikely to have a detectable effect on the higher food chain since such a small source of food is irrelevant to its predators. Similarly, one would think that small populations of predators are unlikely to have any effect on a prey of sufficient population to be a nuisance to man.

This reasoning, however, does have counter examples. A rare moth, Cactoblastis, tends to control the beavertail, Opuntia cactus, in places where the cactus grows naturally. Thus, when the cactus was introduced moth-free to Australia, it promptly overgrew valuable grazing lands. The moth, then introduced into Australia temporarily grew to large populations until the cactus once again was rare. With its food source reduced, the moth then became rare as well. The predator-prey cycle is such that even small populations of predators can check a potential prey pest problem. Critical to this example, of course, is the ability of the rare species to multiply quickly when the pest (food source) reappears.

Although the moth may qualify in this regard, most endangered species are probably incapable of such a rapid recovery of numbers. Thus, it is an open empirical question whether or not indirect use is a sizable component of the benefits of maintaining an endangered species, and the presumption must be that they are not. This is particularly true since most noted endangered species are just below man in the food chain.

SECONDARY USE

It is clear from the market for nature photography, naturalist lectures, and books about nature that people need not directly interact with a site to get value from its existence. Many end users obtain benefits from nature through an intermediary who has gone to the site and converted this experience into an intermediate product: a book, movie, or lecture. There is no question but that the intermediate product has value. One could add up all the money spent on calendars, photographs, books, and movies as a measure of the value of this intermediate product. But the issue is not the value of their products but rather what is the relationship between the natural site or the endangered animal and their product. In particular, there are at least three questions to ask. (1) How much would the total value of secondary products be reduced if a species or natural area disappeared? (2) Is this secondary value already captured by direct use measures? (3) Does the very existence of these secondary products increase or decrease the need to keep the species alive?

If there were no costs to writing and producing a publication (book, photograph, or movie) about an endangered species, the species itself could claim the entire value of the publication. Without the species, the book could not have been written and society would have lost the opportunity to enjoy this good. In reality, of course, it costs a great deal to produce such publications. Without the species, the book would be lost but all the printer's, editors, and writer's time and materials would be freed to print another book. It is the difference in value from the nature book on this particular endangered species and the next best book which is the <u>net</u> contribution of the endangered species.

For example, it is evident that the photographs of Yosemite National Park by Ansel Adams are truly exquisite pieces of art. What if Yosemite had been destroyed before Adams had reached the valley? Would he have instead produced just as beautiful images of alternative sites? Would Yosemite be of less value if Adams had become a fashion photographer instead of producing his nature pictures? It is not at all clear that specific natural sites, in general, and individual endangered species, in particular, generate large net secondary benefits.

Suppose it were agreed that a particular species did contribute significantly to the net value of a book or movie. Is this net value already captured in the direct use measure of the site? The answer depends upon the technique used to measure the value of direct use. For example, if a contingent valuation approach were used and the author or cameraman was interviewed, the value such individuals should place on access to the site is equal to the value of the site in their enterprise. Similarly, if a travel cost technique is used and the artist's relatively high demand for access to the site is measured, this direct use measure could conceivably capture all of the net secondary benefits.

Perhaps the issue of secondary benefits is not that another good must be measured but rather that the measure of direct use must be sensitive to the fact that users creating secondary products may have unusually high demand for these resources and should be carefully sampled. Thus the representative of a bird society collecting data for an annual lecture, the film maker creating a documentary on an endangered species, and the writer seeking direct contact with nature may all be high direct use demanders not because of their individual tastes but as representatives of a large clientele. It may therefore be important to carefully measure the direct use of these artistic producers to estimate a representative value of the resource.

Although it might appear from the above arguments that little importance is placed on the efforts of naturalists and others to reach the general public through movies, books, lectures, and photographs, such a conclusion should not be drawn. It is entirely plausible that these secondary products have a major beneficial impact on direct use. Certainly many visitors to wild and natural sites have been spurred on by books and documentaries of the very sites they choose to visit. The widespread increased direct use of natural sites in the United States is probably due at least in part to the growth in this country of a vast array of revealing and sensitive books, movies, and photographs of nature. This "inspirational value" on direct use, however, should be captured by intertemporal measures of direct use. As long as the trend in direct use is measured well, these secondary benefits should not be added to direct use measures. To complete my discussion of the role of secondary products on the need to keep species alive, I must introduce the concept of existence value. The discussion of whether or not secondary products increase or decrease existence value is discussed in the next section.

EXISTENCE VALUE

Existence value is a concept first raised by Krutilla (1967) in his often cited article on the benefits of conservation. Existence value is a payment individuals are willing to make to preserve a species (or natural area) which they have no intention of ever visiting. People supposedly obtain pleasure just from the knowledge that a creature or natural wonder is being preserved. Since it is independent of use, existence value clearly should be added to direct use as a measure of total preservation value.

There have been several attempts to measure existence value using contingent valuation methods. Schulze et al. (1983) estimated that 99% of the value of preserving visibility in southwest parks could be existence value. Walsh et al. (1984) find almost 20% of the value of preserving wilderness in Colorado is existence value. Finally, Greenley et al. (1981) estimate that 17% of the value of saving water quality in the South Platte River is existence value.

Although existence value is an intriguing concept, it is easy to be skeptical about the empirical results. After all, existence value is supposed to be completely devoid of potential use value. Is it possible these hypothetical questions were posed to eliminate all potential use? For example, Walsh et al. (1984) ask what percentage of total willingness to pay for wilderness preservation is due to the satisfaction from knowing that it exists as a natural habitat for fish, plants, wildlife, etc. At first glance, it would appear this question is asking why the respondent would value going to a well known and visited site (because it is natural and not developed). Nowhere in the question is the caveat that the person must not visit the site, since even potential visits are reflected in measures of direct use. Greenley et al. (1981) assume that existence value is what nonusers are willing to pay to preserve water quality. Again there is no careful caveat to prevent direct use from entering the evaluator's judgment. It is highly likely that most, and possibly all, of the measured existence values are merely capturing a component of use value either for the respondent or on behalf of the respondent. As such, it is not at all clear that preservation value is the sum of use and existence value.

In addition to being difficult to quantify, there is reason to suspect that existence value may not even exist. After all, why would people value something with which they have no contact and for which they cannot anticipate contact. What difference would it make if it was not there? How would they even know it was not there when it ceased to exist? Clearly, if a lot of us possessed substantial existence value, it would give a shyster a lot of room to maneuver as he promised to preserve things but never did. Could we rightfully complain? Perhaps we could insist on third party verification that the creature remained. Would we pay a lot to hear a "yes," or would we want to know more. Perhaps a film of the creature and an occasional book would do. But if this is all we want to know of the creature's existence, what would stop the shyster from making several such films and books and then destroying the creature. Do the books and films become a substitute for the long dead creature. It appears that most people's notion of existence value is probably another form of use value, and probably should not be added to direct and secondary use value.

To test for existence value, it is necessary to eliminate potential use from consideration. For example, how much would you pay a millionaire who owned his own island to preserve some small fish in the middle of his property if it was clear that public access would never be granted to the area. Or, how much would you pay to protect an endangered mammal who lived safely on a radioactive island that could not even be approached for a thousand years by human beings. Casual empirical evidence suggests that true existence value is zero.

BEQUEST VALUE

Another source of the benefits of conservation listed by Krutilla (1967) is bequest value. Bequest value is how much an individual is willing to pay to have more capital or land devoted to conservation than alternative uses for his children to enjoy. Like existence value, this concept has been quantified with contingent valuation methods by Walsh et al. (1984) and Greenley et al. (1981). Bequest value was found to be about 18 and 14% of total preservation value in the two studies, respectively. "Bequest value is defined as the willingness to pay for the satisfaction derived from endowing future generations with wilderness resources" (Walsh et al. 1984).

As discussed in the introduction, the present value of use is the discounted value of all future use of the resource. It is very difficult to tell in what way bequest value differs from the string of discounted future benefits of users. Bequest value appears to be future user value called by a different name. Assuming it smells as sweet, it seems reasonable to continue using the concept of present value of use. If future use is properly incorporated into direct use measures, bequest value is redundant and should be ignored.

SCIENTIFIC VALUE

Many fields of science gain empirical knowledge through experiments made under artificial and controlled settings. It is evident, however, that nature itself performs experiments although without the care of controls. Although these natural experiments can be difficult to analyze because of the complexity of the settings, they provide opportunities which might otherwise be lost. For example, what would happen in the long run if one took a cold water mammal and placed it in warm water? Over 200 years, what behavioral and possible physiological changes would be adopted by the animal? Clearly, a controlled experiment along such lines of inquiry could be established but only at considerable cost and a great deal of patience. By studying the endangered monk seal in Hawaii, the answer to this question might be evident with just a modest program.

Endangered species may contain or provide valuable information which would forever be lost upon extinction. The scientific value of endangered species is the present value of all the knowledge the species could provide if it remained alive. Of course, to obtain knowledge from a species it must be studied. With 50,000 vertebrate species and over 2 million animals, it would help to know which species are likely to contain unique scientific information.

Many animals used in laboratory experiments are valuable because they, in one way or another, resemble man. They are also valuable because they are numerous, and so individuals are relatively expendable. This affords scientists additional latitude not permitted on human subjects. Clearly endangered species are unsuitable for this type of work because (perhaps for different reasons) they are just as valuable as humans. Such care has to be taken of their welfare that only gentle experiments can be performed. The gentler the disturbance of a creature, the more subtle his response, and so ever more sensitive measurements are needed on larger populations. Clearly, large population experiments are also difficult with endangered species.

A final note is that scientific value is not generally long lived. Once a species provides the key to a scientific issue, it is no longer useful for that purpose. Thus if an endangered species provides a new biochemical which is then produced by artificial means, it is no longer necessary to preserve the species. The scientific value of a species is the present value of all the clues the population has yet to provide. Once a discovery is made, the scientific value of the species is reduced. (A possible exception to this rule is the discovery that the species is ideal for a line of experimentation. But as discussed earlier, endangered species are particularly inappropriate for this type of research because of their small numbers.)

CHEMICAL MINING

Wild species have been quite useful over the years to agriculture, medicine, and industry as a source of genetic material and organic compounds. Some 40% of the increase in American agricultural productivity has been attributed to improved genetic strains (Myers 1983). One of the most important tools of these geneticists is a large gene pool--fed by wild stocks. For example, a new strain of wild corn, *Zea diploperennis*, was recently discovered in the Mexican mountains. Not only is this wild corn resistant to several of the insects, fungi, nematodes, and bacteria which attack our current crops, but it is also a perennial. If this strain can be crossed with current corn into a successful perennial, it could save farmers millions of dollars in plowing and sowing costs.

Wild organisms have also been the source of almost half of the prescription drugs. The rosy periwinkle from tropical forests provides a cure to child leukemia, a Greek species of foxglove controls high blood pressure, a Caribbean sponge is effective against herpes encephalitis, and pufferfish produce compounds which block nerve transmissions, to name just a few of the sources of today's medical chemicals.

Industry, as well, borrows from the wild for many of its products. Tropical coral reefs provide stabilizers and emulsifiers which go into hundreds of products including plastics, polishes, waxes, detergents, etc. Organic chemicals from living plants, phytochemicals, could also serve as a substitute for petroleum-based chemicals if the price of crude oil gets too high.

The fact that man depends upon wild plants and animals is unquestionable. The issue, however, is whether all wild plants and animals should be preserved just because some species have become useful. Ecologists estimate there are 250,000 flowering plants and between 2.5 million and 12 million animal species. To argue that it would be foolish to wipe out all of these wild species is not to conclude that each species is valuable. Even a cursory screening of each of these species would probably be sufficient to identify which species is worth keeping. The probability of finding a valuable species from these vast pools is generally low, so that most wild species cannot be justified as a source of useful chemicals.

The application of chemical mining to endangered plants and animals has the additional problem of destroying individual specimens. Clearly, if the species population is small, it will be a poor source of large quantities of any chemical. Direct chemical mining of the species would either become a small renewable resource effort or a temporary and fatal nonrenewable resource collection. Direct chemical mining of an endangered species could be attractive only if the species could be made to grow quickly with help from man. Even here, the danger of taking the species from the wild to cultivated environment could lead to its accidental destruction.

The most likely avenue by which an endangered species could provide medical, agricultural, or industrial assistance is by being a source of information and not a source of direct chemicals. This perspective is discussed more fully in the previous section on scientific value.

In conclusion, most endangered species have no known chemicals which are of special value for agriculture, medicine, or industry. The few species which are clearly useful, like Zea diploperennis, can justify their existence solely as a source of new genetics or chemical material. However, even in these special cases, the fact that a wild species may be endangered (be close to extinction) lowers its potential value as a chemical source because experimentation is severely limited by the risk of destruction. Even the process of screening the plants for potential benefits must be curtailed by the possibility the search may itself lead to extinction. Thus, although an occasional species has direct and substantial value to agriculture, medicine, or industry, a collection of a thousand unknown but endangered species probably has a low expected value for chemical mining.

QUASI-OPTION VALUE

The concept of quasi-option value was first discussed formally by Arrow and Fisher (1974). They posed a situation where an irreversible decision is being contemplated under uncertainty. The decision could be made now or it could be postponed until more information was available (the uncertainty reduced). The value of waiting is quasi-option value. This concept clearly pertains to endangered species because once the decision for destruction is made it is irreversible. It is also true that the present value of the future streams of benefits of preservation and possible development is uncertain.

As Conrad (1980) notes, quasi-option value is the present value of more information. Because future benefits of information must be discounted, for quasi-option value to be large, we must be learning a lot about the benefits and costs of preservation in the near future. It is only if we can make better decisions about whether to preserve or destroy in the near future, that it pays to postpone making the decision. Given our slow accumulation of information about the long-term value of wild species and the high cost of collecting this information, quasi-option value will tend to be low.

In specific cases, however, quasi-option value could be sizable for a short period of time. For example, suppose a new species of animal or plant were discovered in an untraveled part of the world. A perfect example would be the discovery of Zea diploperennis in Mexico. Until experimentation with this corn is completed, it would probably be foolish to wipe out its habitat. The flow of information coming about the potential usefulness of this species clearly warrants postponing its destruction. Quasi-option value, when it exists, will tend to be short lived. The very process of reducing the uncertainty about the benefits of a species, the source of the quasi-option value, eventually leads to a more or less certain choice. At this point, quasi-option value falls to zero, and the species is either kept or destroyed based on its known other benefits and costs.

It is also clear that ecosystems or species which do not have sufficient potential to attract research interest will not generate enough new information to warrant a positive quasi-option value. As a meaningful empirical concept, quasi-option value only applies to species which are of current research interest.

OPTION VALUE

Although quasi-option value and option value have similar names and deal with questions of uncertainty, they are distinct concepts. As just discussed, quasi-option value is concerned with intertemporal decisions under uncertainty which are irreversible. Option value, in contrast, is a static concept concerned with valuing projects under uncertainty. As first vaguely expressed by Weisbrod (1964), option value was described as what people would be willing to pay above consumer surplus simply for the option (or chance) to have a good or service. It was widely felt by environmental economists (Cichetti and Freeman 1971; Krutilla and Fisher 1975), that the option value for conservation areas including rare species would tend to be positive. Thus, in addition to the expected value of all the utilitarian benefits listed in this paper, there would be an added "risk premium" made in favor of preservation.

Subsequent research by Schmalensee (1972), Anderson (1981), Graham (1981), Bishop (1982), Mendelsohn and Strang (in press) has shown that option value is not the same as a financial option. With a financial option, a purchaser has the right to buy a good at a specified price in the future. If the price of the good becomes higher than the specified price, the purchaser can exercise his option and a profit. If the price of the good ends up being lower than the specified price, the purchaser of the financial option simply lets his option expire. Option price, in contrast, requires the purchaser to buy the good at the specified price. If the price of the good becomes higher, option price resembles the financial option because the financial option will be exercised. If the price of the good is lower than the specified price, however, the purchaser of option price must buy the good at the specified price. Unlike the financial option, the purchaser must always purchase the good at the specified price. Because the actual price of the good may be lower than the specified price, option price may lock the purchaser into a losing position.

Expected consumer surplus is the measure of what people would pay for the actual service or good they receive. The consumer surplus payment consequently varies with the level of service. The option price payment, in contrast, is the same regardless of the actual level of service. Let us contrast these two measures in a simple example. Suppose people's tastes were such that they would be willing to pay a dollar for each whale they see during a single boat trip. Thus, if no whales are sighted, their willingness to pay would be zero. Under expected consumer surplus, they would pay nothing but under option price they would have to pay a specified price. Similarly, suppose they saw 10 whales (and the average on all trips is 5), under consumer surplus they would have to pay $10 but under option price they would have to pay only the specified price. Thus the difference between expected consumer surplus and option price is the method of payment. Under consumer surplus, you always pay for what you get. Under option price, you always pay the same amount, whether you get it or not.

Option value is a relevant concept because many public projects are financed from general tax revenues. Thus, one pays a single amount for each park and each species regardless of the actual value of the good. In contrast, the park tends to be valued according to its expected consumer surplus, that is, the actual value to users. Thus our measure of value is inconsistent with our measure of payment. The measure of value is expected consumer surplus, the method of payment is option price. If option price exceeds consumer surplus, public conservation projects should be given a risk premium benefit. If consumer surplus exceeds option price, public conservation projects should be assigned a risk premium cost.

Because option price freezes the purchaser into buying the good at one price, it is not necessarily greater than expected consumer surplus. In fact, option price can be smaller or greater than expected consumer surplus. More importantly, the difference between the two measures relates to the absolute value of the good and subtle changes in the marginal utility of income. As Freeman (1984) has shown, in most circumstances, this difference is likely to be small. As first recommended by Schmalensee (1972), it seems reasonable to accept expected consumer surplus as a close approximation to the ideal measure in an uncertain world.

In contrast to the results of these theoretical inquiries, Greenley et al. (1981), Brookshire et al. (1983), and Walsh et al. (1984) using contingent valuation methods all conclude that option value, the difference between option price and expected consumer surplus, is large and a significant fraction of preservation value. The relevance of these findings, however, is seriously undermined by the definition these authors use for option value. Walsh et al. (1984) define option value as the annual payment required to retain the option of possible future recreation use. This clearly is not option value at all but rather just option price. In the Walsh et al. (1984) paper, option price is clearly less than expected value. In Greenley et al. (1981), option value is defined as what the user would be willing to pay for perfect information about a site next year. Not only is the question vague because the initial uncertainty is not specified, but it is actually a definition of quasi-option value and not option value at all.

On a more theoretical level, Conrad (1980) charges that option value is just the value of perfect information. Option value is clearly positive if this is correct. Conrad, however, has simply redefined option value. He defines an option as the opportunity to delay an irreversible decision until perfect information is available. This is a very different notion from paying a constant price for a good regardless of the true state of nature. Conrad confuses option value with quasi-option value and correctly deals only with the latter.

Another source of confusion is the summary article on option value by Bishop (1982). After an excellent review of the past literature, Bishop attempts to extend the literature by discussing supply side uncertainty. He comes to the conclusion that uncertainty about supply side parameters leads to a positive option value. In a separate article Smith (1983) attempts a similar extension using Cook and Graham's (1977) model of insurance against irreplaceable assets. Smith argues that option value is positive whenever the good in question is irreplaceable.

Clearly, both Bishop's and Smith's arguments could apply to endangered species since both supply uncertainty and irreplaceability are characteristics of endangered species. Both arguments, however, are faulty for different reasons. Bishop's supply side argument raises a special case where option value would be positive. There is little reason to believe, however, that in general people would prefer to make a constant payment for a natural area of variable quality (option price) rather than a payment which varied with the quality of the site (expected value). If the marginal utility of income is positively related to the realized benefits (quality) of the site, option value will be negative. Smith, in turn, confuses option price and Cook and Graham's ransom payment. A ransom payment is what an individual would pay for a good in a certain world. Option price, in contrast, is a certain payment for a good in a random world. The model Smith constructs in his paper implies that the benefits of a project are the same regardless of the outcome of an uncertain world. In such cases, option price and expected value of consumer surplus are also the same. Despite this, Smith asserts he shows option price is larger than expected consumer surplus. The confusion begins, but may not be limited, to the difference between a ransom payment and option price.

A final line of argument raised for a risk premium uses a different notion than option value. For completeness, however, it deserves discussion. Bishop (1978) argues that endangered species should be given a risk premium as part of a game theory model. In Bishop's model, society can or not attempt to protect some endangered species. If it does not protect the species, society might lose it and receive loss y. If it does protect the species, he argues that the worst that can happen is that the protection expense x was unnecessary. As long as $y > x$, the minimax strategy minimizing the worst case, is to protect the species. Bishop pushes this argument further. The potential benefits from the species may have a broad distribution. Evaluating y as the highest possible value of the endangered species, it is likely to be greater than x, the certain cost of foregoing development. Consequently, all endangered species should be preserved unless their existence requires excessive costs.

As Bishop himself notes, this is an entirely conservative approach. Even though the species may have a 1 in 10 million chance of providing benefits, the argument asks us to treat the species as though it provided benefits for certain. The minimax strategy is fine if the worst case is likely to occur but it is much too rigid an approach if the worst case is a rare event. Life would be very tedious if our sole aim was to avoid all the minute chances of having an accident. Clearly the likelihood of a bad accident should be included in our decision making calculus.

A second point not recognized by Bishop is that the worst possible case is not extinction at all. The worst case is that we spend x on preservation and yet the species goes extinct anyway. Since there is no expenditure which will guarantee survival, our best minimax strategy is to not preserve anything regardless of its value.

In conclusion, it appears that option value is small and may be either positive or negative. Given that we have few means available to determine option value, the sensible approach seems to be to ignore it since it does not bias our decisions. Consequently, the appropriate measure of the value of endangered species given uncertainty is the expected value of all benefits.

NONUTILITARIAN BENEFITS

Most of the discussion of endangered species benefits concerns how plants and animals may be useful to man. The underlying notion is that it may be in man's self-serving interest to maintain many species. Some philosophers naturally object to this homocentric viewpoint of nature. Some people do not believe nature exists just for man's pleasure. In fact, Stone (1972) argues that all of nature should be given rights (legal standing) to defend its interests against man.

Existence is primarily a function of adequate resources. Every species needs a certain amount of the correct habitat to survive. The more of that habitat, the higher the probability of survival. Survival can consequently be viewed as an allocation of habitat (resources) problem. Given the total resources of the world, how should they be allocated among species? The problem of survival among species closely resembles issues of income or wealth distribution among people.

Borrowing from Rawls (1971), let's try to determine the optimal allocation of habitat across species. The discussion in the rest of this paper has focused upon how man would like the resources allocated. In this section, we would like to expand the number of voters to include other species. Rawls suggests that one way to think about a fair distribution is to step through a "veil of ignorance." Suppose we did not know that we would be the dominant species. In fact, suppose one could be anywhere in the distribution of species. What allocation of resources across species would one vote for?

Rawls himself argues for a minimax solution. We should try to minimize the worst possible case by making the worst off species as well off as possible. The argument resembles Bishop's (1978) plea to protect all species unless the cost is excessive. Although the definition of excessive cost remains vague, the implication of these arguments is that man (and plants and animals cultivated by man) ought to return substantial habitat to creatures man has little interest in. There should be substantially less commercial forest, agricultural land, grazing acreage, developed land, and probabaly much fewer people. Perhaps only 1% or fewer of the world's population of humans should be allowed to remain.

As discussed by Bishop (1978), the minimax strategy is exceptionally conservative. Why not take a chance that one could become extinct rather than have to share all resources almost equally across species. Almost equal sharing across some 2 to 12 million animal species would almost surely leave most species permanently in a dire subsistence state. Many people would probably prefer to take a chance of dying to get a better life for them and their children rather than having the certainty of permanent poverty. Extinction may be an acceptable risk if the potential rewards to the remaining species are large enough.

Another issue of serious import is how would all the other animals vote. Is man the only animal concerned with its own interest, whereas, the rest of nature maintains a perfect balance? Does nature abound with examples of altruistic behavior across species? I believe there are very few examples where animals have reduced their own welfare consciously to protect other species. Most animals kill as much as they want to eat. They don't willingly go hungry because their food source is weak and needs replenishment. If predators go hungry, it is because they cannot find their source prey, not because they are sorry for them. The law of nature appears to be the law of survival. The law of survival says the dominant animal acts in his self interest. The behavior of most animals would suggest that they would vote for a distribution of resources determined by the interests of the dominant animal. Far from protecting all species, this belief is a foundation for a homocentric utilitarian approach. Man, as the dominant animal, should work to maintain species only if they are valuable to mankind.

CONCLUSIONS

This paper reviews the literature written about conservation and endangered species. The literature identifies nine sources of benefits that living resources might provide man. It is argued that existence value, bequest value, and secondary benefits are redundant and capture benefits measured elsewhere. Other benefits which might be large for some wild species are probably near zero for endangered species because of their small populations. These benefits include direct consumptive use, indirect benefits, scientific information, chemical mining, and quasi-option value. It is further argued that option value could be either positive or negative, is hard to measure, and is probably small. Thus, despite the considerable uncertainty surrounding measurements of the benefits of species preservation, the best approach is to value benefits at their expected value. The major conclusion of the paper is that nonuse values of endangered species are near zero and irrelevant. The focus of empirical work should be upon measuring the use values of endangered plants and animals.

The major benefit of maintaining endangered species lies in nonconsumptive direct use. It is what people are willing to pay to interact with the species in its native habitat. It is the sum of these payments across all users--tourists, hikers, naturalists, writers, moviemakers, etc.--which is the social value of the resource. Projecting this stream of benefits indefinitely into the future and taking its present value yields the social value of each species.

If this hypothesis is correct, that species ought to be preserved because of their nonconsumptive direct use, it gives new perspective to the optimal management of wild species. An animal which people enjoy seeing such as a seal, whale, elk, or buffalo should be protected whether or not it has a small population. The value of the species is not just a function of the size of its population or probability of extinction, but also a question of its appeal. Surely some animals are valuable because they are almost extinct, but some species so closely resemble surviving species that their loss would hardly be noticed. As a point of evidence supporting this notion, even biologists are only aware of a small fraction of the species which go extinct each year. Typical users are probably aware of even fewer of the losses. Some species are clearly worth preserving more than others.

Second, protection of endangered species should not be accomplished to the exclusion of all nonconsumptive use. Surely, if the primary value of maintaining a whale population is the benefits achieved by onlookers, it would be foolish to overprotect the whale by banning all approaches by man. Any overzealous regulation which neutralizes the reason for keeping the animal alive is hardly in the interest of society or the animal. Clearly, one should look for a balance between preserving the animal and maintaining use. Similarly, if the benefits of a species are in viewing rather than scientific information, tour boats should be given preference of access over scientific experimenters.

Third, although the tone of this paper is highly critical of the multiplicity of specialized benefits supposedly provided by endangered species, it is not argued that preservation benefits are likely to be smaller than heretofore expected. It could well be that correct measurement of nonconsumptive direct use will reveal that the preservation value of many endangered species is, in fact, higher than is now expected.

Fourth, nonconsumptive direct use can be measured and evaluated. Contingent valuation, multiple site travel cost, and hedonic travel cost are existing techniques which can be brought to bear on measuring the value of direct use. If, in fact, preservation value is nothing but nonconsumptive use value, then the benefits of preserving individual endangered species can be measured.

Fifth, the benefits and costs of preserving endangered species should be carefully weighed. Current laws rigidly demand all endangered species be preserved. Although, in practice, the administration of this law has been far more flexible than the law itself, Harrington (1981) and Miller and Menz (1979) are correct in their call for a better allocation of resources towards plant and animal protection. The expenditure of a dollar to save a small irrelevant fish could well be the dollar that could have saved an eagle, whale, or brown bear. Society can ill afford to throw its resources carelessly at vanishing habitats or endangered species.

ACKNOWLEDGMENTS

I wish to thank Samuel G. Pooley, Tim Gerrodette, and Karl C. Samples for their stimulating comments and encouragement.

LITERATURE CITED

Anderson, R.
1981. A note on option value and the expected value of consumer's surplus. J. Environ. Econ. Manage. 8:187-191.

Arrow, K. J., and A. Fisher.
1974. Environmental preservation, uncertainty, and irreversibility. Q. J. Econ. 88:312-319.

Bachmura, F.
1971. The economics of vanishing species. J. Nat. Resour. 11:647-692.

Bishop, R.
1978. Endangered species and uncertainty: The economics of a safe minimum standard. Am. J. Agric. Econ. 60:10-18.

1982. Option value: An exposition and extension. Land Econ. 58:1-15.

Brookshire, D., L. Eubanks, and A. Randall.
1983. Estimating option prices and existence values for wildlife resources. Land Econ. 59:1-15.

Brown, G., and R. Mendelsohn.
In press. The hedonic travel cost method. Rev. Econ. Stat.

Cichetti, C., and A. M. Freeman.
1971. Option demand and consumer surplus: Further comment. Q. J. Econ. 85:528-539.

Clark, C.
1973. Profit maximation and the extinction of animal species. J. Political Econ. 81:163-173.

Conrad, J.
1980. Quasi-option value and the expected value of information. Q. J. Econ. 94:810-820.

Cook, P., and D. Graham.
1977. The demand for insurance and protection: The car of irreplaceable commodities. Q. J. Econ. 91:143-156.

Cropper, M., D. Lee, and S. Pannu.
1979. The option extinction of a renewable natural resource. J. Environ. Econ. Manage. 6:341-349.

Freeman, A. M., III.
1984. The sign and size of option value. Land Econ. 60:1-13.

Graham, D.
1981. Cost benefit analysis under uncertainty. Am. Econ. Rev. 71:715-725.

Greenley, D., R. Walsh, and R. Young.
1981. Option value: Empirical evidence from a case study of recreation and water quality. Q. J. Econ. 66:657-673.

Harrington, W.
1981. The endangered species act and the search for balance. J. Nat. Resour. 21:71-92.

Krutilla, J. V.
1967. Conservation reconsidered. Am. Econ. Rev. 57:777-786.

Krutilla, J. V., and A. C. Fisher.
1975. The economics of natural environments: Studies in the valuation of commodity and amenity resources. John Hopkins Press, Baltimore, Md.

Mendelsohn, R., and W. Strang.
In press. Cost benefit analysis under uncertainty: A comment. Am. Econ. Rev.

Miller, J.
1978. A simple economic model of endangered species protection in the United States. J. Environ. Econ. Manage. 8:292-300.

1981. Irreversible land use and the preservation of endangered species. J. Environ. Econ. Manage. 8:19-26.

Miller, J., and F. Menz.
1979. Some economic considerations for wildlife protection. South. Econ. J. 45:718-729.

Myers, N.
1983. By saving wild species we may be saving ourselves. Nat. Conserv. News. 33:7-13.

Plourde, C.
1975. Conservation of extinguishable species. J. Nat. Resour. 15:791-798.

Porter, R.
1982. The new approach to wilderness preservation through benefit cost analysis. J. Environ. Econ. Manage. 9:59-80.

Rawls, J.
1971. A theory of Social justice. Harvard Univ. Press. Cambridge, Mass.

Schmalensee, R.
1972. Option demand and consumer's surplus: Valuing price changes under uncertainty. Am. Econ. Rev. 62:813-824.

Schulze, W., D. Brookshire, E. Walter, K. MacFarland, M. Thayer, R. Whitworth, S. Dean-David, W. Maln, and J. Molenar.
1983. The economic benefits of preserving visibility in the national parklands of the southwest. J. Nat. Resour. 23:149-173.

Sinn, H.
1982. The economic theory of species extinction: Comment of Smith. J. Environ. Econ. Manage. 9:174-198.

Smith, V. K.
1983. Option value: A conceptual overview. South. Econ. J. 49:654-668.

Stoll, J., and L. A. Johnson.
1984. Concepts of value, nonmarket valuation, and the care of the whooping crane. Texas Agric. Exp. Stn. Tech. Art. No. 19360.

Stone, C.
1972. Should trees have standing? Toward legal rights for natural objects. South. Calif. Law Rev. 45:450-501.

Walsh, R., J. Loomis, and R. Gillman.
1984. Valuing option existence, and bequest demand for wilderness. Land Econ. 60:14-29.

Weisbrod, B.
1964. Collective consumption services of individual consumption goods. Q. J. Econ. 77:71-77.