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From the time of Pigou until recently, the primary issue for economists with respect to the conservation of natural resources has been the optimal intertemporal utilization of these resources. However, the rates of consumption of natural resources during both world wars began to indicate that the resource base would ultimately be depleted. Nevertheless, the view that modern industrial economies can gain a large measure of independence from natural resources due to technological advances has more recently been gaining popularity. The core of this argument is that technological progress compensates for the depletion of higher quality natural resource stocks. There have, however, been warnings that the level of pollution and the deterioration of the physical landscape are increasing.

The traditional focus of conservation economics on reserving natural resource stocks for future generations has been outmoded by technological advances. This concern has therefore been replaced more recently by a focus on how to preserve natural environments for future generations. Traditional conservation economics does not, however, address this issue. In fact, use of Pigou's social time preference to determine the optimal rate of resource use may hasten the conversion of natural environments into low-yield capital investments. This paper therefore discusses how decisions should be made with respect to choices involving actions that will have irreversible adverse effects on natural phenomena. It should be the task of a new economics of conservation to confront the "problem of providing for the present and future the amenities associated with unspoiled natural environments."(778)

At present unspoiled environments are not sufficiently valued. When deciding on the utilization of unspoiled environments, a private resource owner typically looks at all of the alternate uses of the resource, and considers the prospective discounted net income of each use. It is possible that such an analysis would find that the option with the highest net income is also an option that is detrimental to the preservation of the unspoiled environment. The private resource user may then choose this option despite its detrimental effects, although from a social perspective this choice may not be the most efficient.

The efficiency of market allocations is uncertain for several reasons. First of all, unspoiled environments have no substitutes, while natural resource commodities often do. Thus, the private resource owner can not actually appropriate through gate receipts the total social value of the resource when it is used in a manner that preserves the unspoiled environment. The present value of the owner's expected net income values is therefore not a valid measure for evaluating the efficiency of resource allocation. It is also impossible to determine the efficiency of market

allocations when many individuals are dependent on the preservation and availability of an unspoiled natural environment for their real income. In this case, the maximum willingness to pay could be less than the minimum amount that would be necessary to compensate these individuals if they were to be deprived of the natural phenomena in question, so it is not possible to determine whether or not the market allocation is efficient.

Option demand is another basis for questioning the efficiency of market allocations. This demand can be characterized as "a willingness to pay for retaining an option to use an area or facility that would be difficult or impossible to replace and for which no close substitute is available."(780) Option demand may exist even if there are no current plans to utilize the area or facility. If an option value exists but there is no way for the private resource owner to actually appropriate this value, then the resulting resource allocations may not be efficient.

Option values for unspoiled environments may exist for a number of reasons. For example, scientific research is often dependent upon an unspoiled environment to preserve the objects of study, and these environments are also important to maintain genetic diversity (e.g., in agriculture) and to serve as a source of new medicinal drugs (in fact, "approximately half of the new drugs currently being developed are obtained from botanical specimens."[780]). In other cases, the option value may have only a "sentimental basis." Many Americans rallied to preserve the national historic relic "Old Ironsides"; although many of them will never visit the site, they still derive satisfaction from knowing that it exists. Membership in the World Wildlife Fund is similar: individuals contribute to preserve endangered species in parts of the world that they will probably never see. Option value can therefore be relevant both among people active in the market for a particular "object of demand," and for those who place a value on the mere existence of this object.

In practice there are several examples of what a market for these "options" might look like, but they are very imperfect. For example, a small natural area or historical site may be purchased by the Nature Conservancy, an American non-governmental organization. However, the investor often has little knowledge of the special characteristics of the ecosystem in question. In addition, "the serendipity value may not be appropriable by those paying to preserve the options."(781) Most importantly, the greatest unspoiled environments are large scale and not of merely local interest, so all of the problems associated with markets for public goods are encountered in these cases.

The formation and growth of demand for unspoiled environments is also relevant. Of particular interest is the "learning-by-doing" approach outlined by Davidson, Adams and Seneca, which "suggests an interaction between present and future demand functions, which will result in a public good externality, as present demand enters into the utility function of future users."[1] That is, as present populations begin to learn to use these unspoiled environments in situations requiring less advanced skills (e.g., car camping), then in future the "greater will be the induced demand for wild, primitive, and wilderness-related opportunities for indulging self interest."(782) Thus, the utility gained from the existence of unspoiled environments may continue to rise, although the supply of these environments can not be increased. At the moment little is known about these relations, and it is an area needing further research.

In expanding our concept of conservation, we must look further at the potential of technology. While technological advance may help compensate for the depletion of specific resources, the same cannot be said for natural phenomena. Neither extinct species nor the grand wonders can be replicated, and even if they could, the replicas would probably be of little worth compared to the originals. Technological advance may allow ever-increasing production from a given resource base, but "the supply of natural phenomena is virtually inelastic"(783); we can only preserve these phenomena, as they can not be reproduced. Consumption-saving behavior is therefore motivated by both the desire to leave one's heirs an estate, and by the utility that is obtained from consumption. Maintaining the option to enjoy these scenic wonders will depend on their provision as public goods. Given the increasing demand for unspoiled environments and the irreversibility of past losses, it is already clear that the level of well-being in the future will not be as high as it could have been if the conversion of natural environments had been stopped earlier.

At present very little is known about the possible magnitude of the option demand. We need to determine the type and minimum scale of reserves of land-based and aquatic environments needed to avoid grossly adverse consequences for human welfare. On land this could mean setting aside approximately 10 million acres for North America, which is not likely to affect the supply or cost of material inputs to the manufacturing or agricultural sectors. We also need to develop learning-by-doing markets in areas suited to specialized recreation where the preservation of biodiversity is crucial. This policy will help maintain biodiversity for scientific research and educational purposes, and provide the widest choices for future consumers of outdoor recreation.

Notes

1. P. Davidson, F.G. Adams, and Seneca, "The Social Value of Water Recreation Facilities Resulting from an Improvement in Water Quality: The Delaware Estuary," Water Research, ed. A.V. Kneese and S.C. Smith, (Baltimore, 1966), cited by Krutilla, 780.