Endangering the economics of extinction

by Jon D. Erickson

Abstract Species and ecosystems have been assigned dollar values through methods developed by economists. Their value is then measured in financial terms and becomes comparable to any good or service traded in markets. This assignment of economic value to biodiversity and species will not guarantee their protection. In fact, pricing these nonmarket values allows for their direct comparison with market goods on a common metric, allowing for the possibility of optimal economic extinction of a species. In contrast to a market model of choice, I propose a decision framework that incorporates complexity, uncertainty, and limits to substitution between biodiversity and monetized goods and allows for critical valuation decisions outside the market model..

Key Words ecological economics, extinction, nonmarket valuation

From optimal choice to extinction

The core of the broad field of economics considers how to allocate society's scarce resources among unlimited desires. In systems where choices are impersonal, have an impact isolated to a point in time, and require little to no ethical dilemma, traditional economics and market prices are well suited to inform the best (or optimal) choices. Many choices made in well-defined goods and services markets qualify. Examples are many, including the market for basic consumer necessities such as food, shelter, and clothing.

On the production (or supply) side, economics describes the choice to produce another good or service as a balancing act between the cost and benefit of producing the next unit. The choice to produce or consume the next unit of a good or service is what economists refer to as a marginal choice and is argued as the basis for efficient decision making. In competitive markets, the cost of producing the next unit (marginal costs) are typically increasing over the relevant range of production, and the marginal benefits to the firm are synonymous with the fixed price received per unit of output. Competitive firms are price takers and will produce until the marginal cost of the next unit of production equals its market price.

On the consumer (or demand) side, traditional economics similarly frames the choice of how much to consume as a balancing act between marginal cost (which is price on the consumer side) and marginal benefits from consumption. Marginal benefits from consumption are much more difficult to measure and are often based on the economist's concept of consumer utility, an abstraction intended to capture the pleasures of consumption. More utility is always preferred. As consumption increases, the amount of utility received in consuming the next (marginal) unit is assumed to be diminishing to capture a notion of increasing satisfaction at a decreasing rate. How much to consume is determined by equating marginal utility with market price.

This traditional economic view of optimal production, optimal consumption, and market exchange has been expanded to include goods without a well-defined market price. A typical example is the case of an all-you-can-eat pizza bar. After the one-time payment is made, an individual can eat as much pizza as she would like at no additional cost. However, individuals don't consume pizza as if there were zero marginal costs. Marginal cost

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in this case must be expanded to include the nonmarket costs of an additional slice of pizza, perhaps stomach discomfort, weight gain, and embarrassment. Marginal benefit is the utility, or pleasure, gained from pizza consumption. An individual will eat his last piece of pizza when its marginal cost equals its marginal benefit.

Extending the economist's paradigm of choice from market behavior to human behavior may be legitimate in cases such as pizza consumption. It assumes that humans act rationally with perfect information in comparing marginal benefits with marginal costs of choices. Economists have extended this paradigm of individual, rational utility maximization to describe everything from marriage choice to charity donations (Landsburg 1993, Frank 1994). In its strictest interpretation, rational choice theory even precludes altruism because individuals receive good feelings (marginal benefits) in return for seemingly unselfish acts of kindness.

At the societal level, the aggregation of this unfettered individual pursuit of happiness is argued to maximize social welfare (or overall well-being), serving as the cornerstone to free-market economics. Welfare is simply equated with maximizing per-capita utility. Utility is most often equated with material consumption. The value of consuming goods and services is then captured by their market price.

This chain of logic fails to capture any nonmarket attributes of consumption or production, known as externalities. Externalities are joint products to goods or services that are not valued in the marketplace. Therefore, a case has been made for adjusting market prices to capture positive or negative externalities. For instance, a negative externality to most production processes is the joint product of pollution. However, a private producer does not include the social cost of pollution in its pricing decision. In social welfare terms, the market price of the good should be increased to force the social optimal level of production. When positive externalities to production occur, private firms produce too little of a market good or service.

Traditional economics holds that with the "right prices" (prices adjusted for any negative or positive externalities), the optimal production and consumption of market and nonmarket goods and services will result by giving individuals the most extensive system of liberties and choice possible. Government intervention is required only when prices don't reflect externalities. For instance, in the case where production of a good creates pollution that has a negative impact on society, then the good should be taxed at the nonmarket value of the externality, providing the private incentive to reduce production, adopt pollution-abatement technology, or reduce consumption of the good in question.

> "Extinction is forever. Even under an economic paradigm of choice, it may seem that the marginal costs of losing the last members of a unique species through human activity or exploitation would approach an infinite amount compared to a finite market price. Can the irreversible loss of a genetically unique species...be compared to its market value or private costs of production?

In today's environmental protection debate, the design, implementation, and evaluation of policy have revolved around this economic vision of cost–benefit analysis. Because most decisions with environmental dimensions involve costs and benefits over time, a consideration of time preference is added to the analysis. This is captured with a positive discount rate that makes future benefits less enjoyable and future costs less painful, consistent with the market-driven behavior to want now rather than later.

A rational cost–benefit framework conveniently includes wildlife and habitat among market benefits by assigning human use values to their existence—i.e. getting the prices right. Benefits accrue not only through the direct use of these natural resources (e.g., hunting, fishing, nature watching) but also through the utility created by their existence, potential for use, and value to future generations. Wildlife and habitat are assigned a price by observing how much is spent on their use (e.g., recreation expenses or user fees) or through nonmarket survey methods that ask how much consumers are willing to pay for natural resource protection or accept for resource loss. Once wildlife and habitat have been valued with a market price, they are then treated as an income flow and become amenable to standard cost–benefit comparisons. The subdiscipline of environmental economics was born and continues to grow on this foundation of nonmarket valuation and expansion of the realm of cost–benefit analysis (Erickson 1999).

Indeed, the collapse or extinction of an animal species may be optimal behavior under a paradigm of the individual acting at a point in time to maximize profit or utility. Clark (1973) has used standard assumptions of market behavior to demonstrate that if the marginal cost of harvesting the remaining individuals of an animal species is less than the marginal benefit, then the species will be driven to optimal extinction. Even with the right prices assigned, harvesting a species to extinction can occur with sufficient consumer demand and a high positive time preference under a market mechanism of allocation. In economic terms, the opportunity costs of preservation can become too high when compared to insatiable consumer demand and growing incomes.

Clark (1973) specifically addresses the extinction of animal species at the hand of exploitation by targeted human activity. Of course, the extinction of species is occurring across all kingdoms and not just from direct harvesting. Most extinction occurs as an indirect consequence of habit loss from economic development. In these cases, the market model of choice would compare the benefits of developing the next acre of land (or scouring the next square mile of the ocean floor) versus the cost from lost habitat, again in terms of an estimate of nonmarket prices. The amount of habitat is a fixed asset, but will be traded away piece by piece (at the margin) under a market paradigm of choice.

So a rational economist might ask whether it is in our best interest to avert species extinction and limit habitat loss. Should we estimate the right prices, tabulate all the costs and benefits, and formulate a rational response? Are there cases in which the extinction of a species should be pursued, such as smallpox? What is the role of the free market in making these decisions, versus informed scientific debate? The purpose of this paper is to assess the propriety of extending a market model of choice to decisions regarding species protection and biodiversity preservation and to propose an alternative decision-making framework from the transdisciplinary perspective of ecological economics.

An ecological economic perspective on choice

The relatively new transdisciplinary field of ecological economics has emerged in direct opposition to this market model of choice. Ecological economics has been characterized as arising from a different worldview than traditional economics. This worldview considers human beings as only one of many species, their economies as subcomponents of ecosystems, resource scarcity as a physical and absolute constraint, the importance of scale of economic activity, the maintenance of evolutionary processes, and the failure of markets to allocate nonmarket goods (Sahu and Nayak 1994, Krishnan et al. 1995, Constanza et al. 1997, Erickson 1999). Under this worldview, 2 main fallacies of the market model of choice are identifiable regarding species and habitat protection: 1) that substitutes exist or will be developed for basic ecosystem services on which all life depends, and 2) assigning consumer prices to species or habitat does not capture their total value or the complexities and interdependencies of life.

Choice and the fallacy of perfect substitution

Extinction is forever. Even under an economic paradigm of choice, it may seem that the marginal costs of losing the last members of a unique species through human activity or exploitation would approach an infinite amount compared to a finite market price. Can the irreversible loss of a genetically unique species with an uncertain role in an ecological community be compared to its market value or private costs of protection? Under current economic theory, the answer is yes, once it has been assigned a market price. Herein lie the inherit trade-offs implicit in assigning something a market price. If a human benefit can be assigned to an environmental amenity, then it can be allocated and optimized as with any other market good. Price acts as a common metric in a system of market exchange, so, by default, goods and services can be substituted for one another at the margin. In standard economic theory, the existence of substitutes for particular goods and services implies that no particular product (or ecosystem component in this case) is essential to economic activity. The more narrowly a product is defined, the more substitutes are likely to exist.

Under a system based on substitutability, scarcity takes on a peculiar economic meaning. Economic scarcity attempts to capture the value of consuming a resource in the future versus a resource today. Once again, the concept of a time preference is implicit to the economic balancing act of allocating resource use over time. A positive discount rate may seem to imply that we should consume all resources today and leave nothing for tomorrow. However, by valuing marginal units of oil left in the ground, trees standing in the forest, or fish in the sea, the

Northern spotted owl (Strix occidentalis). Can "right prices" value the role of species in complex ecosystems?

economic concept of scarcity balances the value of current consumption with the discounted value of future consumption. Because diminishing utility in increasing consumption is typically assumed, economic logic captures a sense of rational conservation. In this decision-making framework based on marginal values of depleted resources, however, absolute natural resource scarcity is not considered relevant to intertemporal allocation. In fact, the ability to overcome resource scarcities through technological innovation and substitution is often assumed implicitly.

To illustrate, consider the case of declining ocean fisheries. In response to declines in worldwide fisheries productivity, the aquaculture or fish-farm industry is beginning to pick up the slack. Aquaculture currently produces over 20 million tons of fish annually (McKibben 1998), supplementing the global ocean catch. Are fish farms substitutes for ocean fisheries? In a narrow market context, yes. But the more appropriate question for the longer term is: Are fish farms perfect substitutes for ocean fisheries? An ocean fishery is a complex system, with many known and unknown feedbacks and interdependencies. It is impossible to reproduce complex systems with their nonlinear, evolutionary, chaotic relationships. Recent research on global environmental impact of human activities has highlighted the essentiality of some basic ecosystem services, including biodiversity (Daily 1997, Vitousek et al. 1997, Lubchenco 1998). If all production ultimately depends on a nonreproducible natural resource stock, then limits to substitution will ultimately be reached and should perhaps be considered in our decisions to deplete or maintain natural resource infrastructure. Decisions made at the margin do not capture this notion.

The study of island communities illuminates the limits to substitution hypothesis. For example, Brander and Taylor (1998) constructed a model to examine the pattern of rising material well-being, resulting environmental degradation, and eventual precipitous population decline of the Polynesian occupation of Easter Island. Archeological research on Easter Island demonstrates a continued population increase following the decimation of forests and associated island biodiversity and a population crash only after a time lag of several centuries. To investigate this time lag, Erickson and Gowdy (2000) refined the Brander and Taylor model to assess the impact of human-made capital accumulation as a substitute to natural resource depletion. The increase in human population following the decimation of the island forest system was interpreted as showing the ingenuity of our species in finding substitutes for natural resources and adopting other cultural patterns to compensate. However, once the natural resource base had been irrevocably degraded beyond a certain point, collapse may have been inevitable. Given the nonsubstitutability of many basic ecological functions of a natural resource base, human technology was unable to sustain a human population in the very long run.

Bald eagle (Haliaeetus leucocephalus). Economic theory assumes that substitutes exist for particular species.

Choice and the fallacy of right prices

Contingent valuation is a technique used by economists to assign a dollar value to a nonmarket positive or negative externality. Surveys or social experiments are designed to assign monetary value through inquiring about an individual’s willingness-to-pay or willingness-to-accept the gain or loss of goods and services not traded in markets. These techniques have been extended to assign prices to nonmarketable species. The going value of northern spotted owl (*Strix occidentalis caurina*) preservation has been calculated as $95 per year, and the lump-sum willingness-to-pay for sea turtle or bald eagle (*Haliaeetus leucocephalus*) preservation ranges from $12.99 to $254 (Brown and Shogren 1998). Once priced, these endangered species can be included in individual baskets of market goods and compared to individual budget constraints.

Clearly, assigning a price to a species does not guarantee its protection. Protection is not a concern of the market model of choice, which is concerned only with efficient allocation of consumer utility. Utility is modeled on consumption valued in dollars. However, no distinction is made between the necessity of specific goods. For instance, in the consumer’s utility maximization problem, a $100 pair of sunglasses is worth the same as a $100 piece of land. At the margin, this trade-off may seem one to one. However, land is a necessity to economic welfare; sunglasses are a luxury. In social welfare terms, the maintenance of the total stock of land should be much more valuable than the total stock of sunglasses. However, comparing marginal consumption through dollar values (even if corrected for externalities) doesn't capture total social or environmental value. The market portion of price will be determined by the dynamics of demand and supply, and may undervalue the intrinsic social worth of a particular good or service. By assigning price, all goods can be traded on a dollar-for-dollar basis at the margin.

This has long been recognized as the "diamond and water paradox," where the marginal value of another diamond is priced much more than another glass of water, but total value of the 2 are incomparable. It describes the fundamental flaw of measuring utility as price times quantity instead, for example, of weighing the risks of losing species against the gains of more luxury consumer products.

Assigning prices to nonmarket goods allows for this marginal trade-off to occur. Marginal change in many economic systems can be modeled as a continuous, well-behaved functional relationship. Can "goods" such as land, species, clean water, a stable climate, and biodiversity be sacrificed for marginal gain at the risk of total loss? Marginal change in these ecological systems may lead to discontinuous, unexpected consequences. The next fish caught, the next species lost, the next acre developed could lead to a systems crash. How can decisions be made under inherent complexity, interdependency, and uncertainty?

Choice under complexity and uncertainty

Economic, ecological, and social systems are complex. Relationships for the most part are not linear, deterministic, or time-invariant. Through interdisciplinary endeavors, researchers are only beginning to comprehend the interdependencies within and between systems. Most economists will admit that the economic system is not as neatly defined and predictable as their theories imply. Biologists will similarly admit to the complexity of natural systems, the many positive and negative feedbacks that exist in daily growth and maintenance, and an uncertain backdrop of evolutionary change. A sociology or political science perspective adds the complicating factors of culture and the variety of contexts of individual decisions. When economic, ecological, and social systems are considered together, the puzzle becomes overwhelmingly complex. Under this umbrella of complex interdependence, the market model of choice is too limiting for many ecosystem attributes. What guidelines can be followed to aid in making decisions under complexity and uncertainty? Is averting environmental deterioration amenable to technical, deterministic solutions or are the root causes inherently nontechnical, co-evolutionary, and nonpredictable? Can humankind ignore complexity and feedback loops in favor of a course of deterministic progress through technological advancement?

Again, the current state of decline of commercially valuable ocean fisheries provides an illustrative example. Current estimates find that at least 60% of the world's 200 most commercially valuable species are overfished (Williams 1998). This vast depletion of natural capital (a stock of value supplied from nature) has resulted from a complex web of economic, social, and environmental variables. Because of economic forces, an industrial fishing fleet of approximately 37,000 vessels now catches over half of the world's harvest. The advent of freezer trawlers, ships capable of catching and processing over a ton of fish/hour, have helped quadruple the global catch since 1950 (Parfit 1995). The struggling traditional fishing fleet of perhaps 12 million vessels takes the remaining catch. The social variables include a transition from centuries-old fishing traditions to a modern, market-driven, winner-take-all mentality. As incomes in less developed countries continue to grow, customary controls on such common property resources begin to break down (Tisdell 1986). Stories of a vanishing fishing culture and the loss of a caretaker culture are now commonplace (McKibben 1998, Pollack 1998).

These economic and social forces are threatening ecosystems, in addition to individual fish stocks. A recent study by Pauly et al. (1998) measures a progressive move down the marine food web of the international fisheries harvest from long-lived, high-trophic–level fish to low-trophic–level invertebrates and plankton-feeding fish. They conclude that the changes in ecosystem structure are threatening many of the world's fisheries. The authors recommend closure of more fisheries to avoid widespread collapse.

Recognizing such complexity is not in itself sufficient to halt degradation or extinction of natural capital. What is missing is an accounting for uncertainty and a value of the stock of natural capital. Unknown information has value, as does a conservative approach to natural capital protection. A paradigm based on utility or profit maximization can result in the decimation of natural capital and, given uncertainty, could result in regrettable consequences.

Traditional economics has tended to fit a line through complexity and simplify complex systems to solve for equilibriums and steady states that may not exist. However, there is nothing inherent in the economic approach to decision making that says complexity cannot be considered. In fact, development of tools to make decisions under uncertainty is a rapidly evolving area of study in the economics and management science professions. For instance, financial markets have long managed uncertainty through selling futures and options contracts. A futures contract locks a future purchase or sale into a certain price, regardless of the actual spot price in that latter time period. Options contracts represent a right to purchase or sell at a future date. For example, an option to buy a financial asset in the future at a certain price grants the investor the ability to guard against an uncertain price increase. This ability to reduce uncertainty has a value reflected in the price of an option contract.

Particularly with respect to decisions that could have irreversible consequences, cost–benefit analysis can be augmented to include the value of new information as it becomes available. With option values included, decisions to harvest or extract a resource may be delayed until new scientific or economic information is obtained. For example, an option price model of old-growth forestry could result in a decision to never cut, or infinitely preserve the forest (Conrad 1997). This is a step toward improving decisions under uncertainty. However, uncertainty in these models has been included in a more elaborate valuation scheme that depends ultimately on decisions made at the margin and the pricing of nonmarket goods. In other words, applied to decisions of natural resource use, uncertain ecosystem attributes are still valued and allocated by a market mechanism.

A more conservative approach to uncertainty is a safe minimum standard policy. It relies less on economic and more on scientific information to set a limit to exploiting natural capital. The United States Endangered Species Act (ESA) has elements of a safe-minimum–standard approach to species protection. The decision to protect a particular species under the Act requires no cost–benefit analysis. However, critical habitat designation requires consideration of economic impact (Czech and Krausman 1998). The Act recognizes the inherent value of species, but it does not allow for habitat protection without considering the market costs. The conflict between species protection based on science and species protection based on cost–benefit analysis has been one of the main stumbling blocks to the re-authorization of the ESA.

The financial and political costs of species protection also have constrained the speed and effectiveness of management plans. There are certainly constraints and tradeoffs in spending money and time on protecting endangered species. Only 40% of species listed as endangered or threatened have approved recovery plans. Current budgetary constraints allow for species listing at the rate of 100/year, with a backlog of nearly 200 species in need of listing and potentially 3,600 species in need of more information on potential listing status (Brown and Shogren 1998). The priority of species protection also has been based largely on social value and political power, with a greater priority typically placed on avian and mammalian species with great social value and strong political support (Czech et al. 1998). The scientific merit of species protection prioritization has been shadowed by these social constructs.

The market price of the Act has been measured in terms of how money could be better spent. In recent years, to justify weakening the Act or shrinking supporting budgets, this opportunity cost has been measured in funds that could be spent on education, childhood nutrition, medical research, or many other underfunded social programs. However, is this the appropriate comparison? The benefits of species protection might more appropriately be compared to the opportunity cost of reducing luxuries of a consumer-oriented economy and the invaluable necessity of a natural capital base to the economy.

To make this comparison, natural capital must be treated as a stock necessary for long-term economic activity. Economic models are built on maximizing consumer utility, which is typically measured by the flow of per-capita consumption. Under this model, reducing material consumption represents a reduction in utility. Natural capital will increase consumer utility only when depleted, consumed, and flowed into the economy. However, depreciation in natural capital stock does not affect utility in this model. Depletion decreases a stock, but is valued positively because it reflects increased consumption.

Thus, one of the most powerful conclusions from ecological economics is that stocks and flows must be adequately differentiated. Depletion of environmental resources, such as species diversity, is akin to living off capital rather than income. Recognition of natural capital depreciation (as a negative flow) in utility models would favor resource conservation. This requires a realistic assessment of the current impact of human activity on environmental stability, and policy initiatives based less on the allocation of dollar value and more on setting safe minimum standards.

Daly (1980, 1989, 1996) has long argued for an economic system based on the tenets of biophysical limits to growth, limits to substitution, the economy as a subsystem of the ecosystem, and an optimal economic scale. In his work on defining the steady-state economy, Daly built on earlier works of Georgescu-Roegen (1971, 1975), Boulding (1966), and a long line of critical thinking dating to the classical economists of the nineteenth century. The steady-state economy, in contrast to the growth economy, is a physical concept. It is a science-based concept that seeks to maintain a level of capital stock (human-made and natural) with a minimum amount of resource flow from raw material, to commodities and services, to waste (what Daly terms throughput). In the steady-state economy, depletion and depreciation are draws on capital stocks and should thus be minimized. Macroeconomic performance is measured by maintaining throughput rather than expanding income flows. This places the focus squarely on optimal scale.

Market economics has nothing to offer a discussion on optimal scale. Market economics deals explicitly with allocation efficiency. A particular allocation of resources, in the market paradigm of choice, is considered optimal as long as no one can be made better off without harming someone else (called Pareto optimal). The market paradigm of choice applies only to the next unit of consumption, next acre of development, or next individual within a species. As these marginal choices accumulate into an aggregate impact, however, the consequence of ignoring the ultimate scale of our marginal decisions will come into focus. This absolute change from the aggregation of individual, marginal choices is what Kahn (1966) called the "tyranny of small decisions." Once the pricing decision has been made, trading away environmental services threatens the very foundation of society and peaceful systems of exchange (Kane 1999).

Conclusion

The collapse of fisheries is just one example of total human impact on fundamental ecosystem processes. Vitousek et al. (1997) found that over 40% of the earth's land surface has been transformed for direct human use, over half of all accessible surface fresh water is in use, and approximately 60% of terrestrial nitrogen fixation is human-caused. Global deforestation rates are in the range of 200,000 km^2/year, and species extinction is occurring at a minimum of 30,000 species/year or 120,000 times above what is considered normal, or background, extinction of one species lost every 4 years (Leakey and Lewin 1995).

Continued human impact, species extinction, and biodiversity loss are likely under a market paradigm of choice and marginal change. At the extreme, the decision to irreversibly deplete or drive a species to extinction can be shown to be optimal behavior in a market. The fallacies of imposing this market model on nonmarket goods and services include the assumption of perfect substitution, equating social welfare with price, and a failure to recognize complexity, interdependency, and uncertainty in most systems.

Ecological economics has emerged to challenge the market model and present alternatives. Under an umbrella of interdisciplinary discourse, complex systems interdependence, uncertainty, and irreversibility, ecological economics has begun to draw a line between market and nonmarket goods and services. Through this transdisciplinary window, ecological economics argues for well-defined limits to substitution, minimum stocks of natural capital, and preservation of ecosystem function. To the extent that these concepts are used, the economic choice of extinction will become endangered.

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