# A Transdisciplinary Approach to Conservation Land Acquisition

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**Abstract:** *Land acquisition is one of the keys to biodiversity conservation, and it is a transdisciplinary endeavor requiring consideration of natural and social phenomena. I integrated principles of conservation biology, ecological economics, and political science to outline an approach to conservation land acquisition in the United States. American political economy, especially, has profound implications for conservation land acquisition, yet these implications have been largely neglected by public land conservation agencies. I derived three general recommendations for the conservation of biodiversity via land acquisition: (1) relatively inexpensive lands in relatively intact ecosystems should be prioritized for acquisition, (2) fee-title acquisition should be favored over easement acquisition, and (3) low-lying coastal properties should receive lower priority. These recommendations contribute to an ecologically macroeconomic approach to conservation land acquisition, and each will become more appropriate as the sizes of the U.S. and global economies increase. Ultimately, however, the conservation of biodiversity will require a new political economy predicated on sustainability rather than growth.*

Un Enfogue Transdisciplinario para la Adquisición de Tierras para Conservación

**Resumen:** *La adquisición de tierras es uno de los aspectos claves para la conservación de la biodiversidad y es una empresa transdisciplinaria que requiere de la consideración de fenómenos sociales y naturales. Integré los principios de la biología de la conservación, la economía ecológica y las ciencias políticas para desarrollar una metodología de adquisición de tierras para la conservación en los Estados Unidos. La economía política norteamericana, especialmente tiene implicancias profundas sobre la adquisición de tierras para la conservación, sin embargo, estas aplicaciones han sido negadas ampliamente por las agencias de conservación de tierras públicas. Derivé tres recomendaciones generales para la conservación de la biodiversidad mediante la adquisición de tierras: 1) tierras relativamente baratas en ecosistemas relativamente intactos deben ser priorizadas para la adquisición, 2) los títulos de adquisición honoraria deben ser favorecidos sobre las adquisiciones forzadas y 3) las propiedades costeras bajas deberán recibir la prioridad más baja. Estas recomendaciones contribuyen a una aproximación ecológicamente macroeconómica para la adquisición de tierras para la conservación y cada una de ellas será más apropiada en tanto que los bienes de los Estados Unidos y la economía global incremente. Sin embargo, a fin de cuentas, la conservación de la biodiversidad requerirá de una nueva economía política predicada en la sustentabilidad más que en el crecimiento.*

## Introduction

Land not devoted to conservation tends to go into economic production, whereupon native biodiversity tends to diminish (Czech et al. 2000). Public conservation lands are often protected by statutory law and are less exposed to market forces than private conservation lands. Therefore, a key factor in the conservation of biodiversity in the United States is the acquisition of lands by public agencies. Land acquisition for the National Wildlife Refuge System (refuge system) of the U.S. Fish and Wildlife Service (USFWS) is especially important because the refuge system is managed pursuant to

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the "wildlife first" principle of the U.S. National Wildlife Refuge System Improvement Act of 1997 (USFWS 2001).

The refuge system includes 536 refuges encompassing over 38 million ha, including over 31 million ha in Alaska (USFWS 2000). Refuges are concentrated along the coasts (140 refuges) and in the prairie pothole region (60), lower Mississippi River Valley (35), and interior California (27). Outside of Alaska, the most expansive refuges are in the Southwest, Great Basin, and northern Great Plains. Refuge system habitats are approximately 37% wetland and 63% terrestrial (USFWS 1993).

The geographic distribution of refuges reflects a historic focus on migratory waterfowl (Hawkins et al. 1984) and, to a lesser degree, large ungulates (Riley & Riley 1992). The U.S. Endangered Species Act of 1973 broadened the scope of refuge system land acquisition to include the preservation of threatened and endangered species. The U.S. National Wildlife Refuge System Improvement Act of 1997 directs the Secretary of the Interior to "plan and direct the continued growth of the system in a manner that is best designed to . . . contribute to the conservation of the ecosystems of the United States." As a result of these historic and recent mandates, refuge-system lands are devoted to the conservation of native vertebrates, plants, macroscopic invertebrates, vegetative communities and other categories of ecosystems, and ecological integrity (Gergely et al. 2000).

Many of the earlier refuges were inexpensive to establish. Large refuges in the West, such as Sheldon (Nevada), Hart Mountain (Oregon), and Desert (Nevada) national wildlife refuges, were simply withdrawn from the public domain. Refuge-system acquisitions have become much more expensive in recent decades, however, especially for the 57 refuges established pursuant to the U.S. Endangered Species Act and especially for coastal properties. For example, 14.44 ha of coastal property at Archie Carr National Wildlife Refuge in Florida has cost the USFWS $9,628,565 since it was established in 1991 (USFWS 2000).

In development of a land acquisition strategy, whether for the refuge system or other conservation lands, several disciplines are particularly relevant, including conservation biology, economics and politics. I seek to outline the rudiments of a conservation land-acquisition strategy—suited particularly to the refuge system but variably applicable to other conservation land systems—that incorporates conservation biology, economics, and political science.

## Conservation Biology and Ecological Economics

Development of a national land-acquisition strategy requires an ecologically macroeconomic approach. Although microeconomic studies can be useful for local managers and policy-makers, the results can be misleading when extrapolated to a national or global scale. For example, Power (1996) found that some local economies in the western United States are no longer centered around natural-resource extraction, yet all economies are ultimately based on agricultural and extractive sectors. This is readily apparent when national and global economies are studied (Boulding 1993).

The ecological principles most relevant to conservation land acquisition that merge conservation biology with ecological economics are niche breadth, carrying capacity, and competitive exclusion. The principle of competitive exclusion is that no species succeeds except at the expense of other species (Pianka 1974). The underlying assumption is that each species has a carrying capacity, and therefore the collective set of species has an aggregate carrying capacity. No species can claim a larger share of aggregate carrying capacity without infringing on the niches, and therefore carrying capacities, of other species.

Aggregate carrying capacity varies with astrophysical, geological, and evolutionary processes (Fortey 1998). Simultaneously, species evolve niches that help alleviate competitive pressures (Begon et al. 1996), having the effect of increasing aggregate carrying capacity. Even then, an ultimate or final aggregate carrying capacity is defined by the first and second laws of thermodynamics (Georgescu-Roegen 1971). What is immediately relevant to conservation land acquisition, however, is that when a species succeeds in an unprecedented manner, at a much faster rate than can be explained by astronomical, geological, and evolutionary processes, the principle of competitive exclusion is fully engaged. The implication is that, due to the tremendous breadth of the human niche and the technologically boosted rate of its expansion, the scale of the human economy expands at the competitive exclusion of wildlife in the aggregate (Czech et al. 2000). Evidence for a fundamental conflict between economic growth and wildlife conservation is both theoretical (Czech 2000*a*, 2000*b*) and empirical (Czech et al. 2000; Naidoo & Adamowicz 2001). As with most long-term conservation tools, and by the definition of conservation, a system of conservation lands amounts to a restraint on human economy.

## Ecological Economics and Political Science

During the classical era of academe, economics and politics were considered inextricable: those who studied economic phenomena were engaged in the study of "political economy" (Heilbroner 1992). In the history books the erstwhile political economists are called "classical economists." The scope of the classical economists included macroeconomic issues such as unemployment, inflation, and economic growth.

Classical economists combined not only economic and political affairs in their studies but tended to have a workable knowledge of the "economy of nature," wild and domesticated. Adam Smith, David Ricardo, and Thomas Malthus, for example, knew much about nature, especially related to agriculture. This helps explain why Malthus had a profound intellectual effect on Charles Darwin, who in turn had a similar effect on the great synthesizer of classical economics, John Stuart Mill (Hodgson 1996). The systematic and simultaneous study of economics, politics, and ecology during the classical era should not be lost on the conservation biology community, which distinguishes itself from the broader ecology community by its transdisciplinary nature (Soulé 1985).

The extrication of economics from transdisciplinary political economy at the beginning of the twentieth century resulted in a new paradigm: "neoclassical" economics (Heilbroner 1992). The isolation was artificial and is now seen by many as a major shortcoming of neoclassical economics (Hall et al. 2000). Gaffney and Harrison (1994) attributed the isolation to the influence of American land barons, who were adamant opponents of Henry George's proposal for a land tax, on economics schools in the United States. Whatever the cause, the shortcoming is no more apparent than at the nexus of economics and politics. After all, a long-cited definition of politics is "who gets what, when, and how" (Lasswell 1936), whereas economics is the "the social science that deals with the production, distribution, and consumption of goods and services" (American Heritage Dictionary 1992). The overlap of subject matter is almost total. What has come to distinguish neoclassical economics from political science is largely methodological. Neoclassical economics became much more quantitative and abstract than political science (Galbraith 1987).

Perhaps as a result of the quantitative/qualitative methodological distinction, the foci of the two disciplines are also distinctive. Political science tends to focus on who (e.g., interest groups) gets what, and why (e.g., social movements) (Schneider & Ingram 1997). Economics focuses more on what (especially material goods and services) is gotten and how (i.e., allocation and distribution) (Daly 1997). Just as there is continual overlap and interaction between ecology and economics, however, there is likewise between economics and political science. "Public choice theory," for example, is a tradition of policy analysis that combines political science and neoclassical economics to describe how the market functions to allocate resources (Schneider & Ingram 1997). I therefore invoke classical terminology by referring to the overlapping and interacting issues of politics and economics as political economy.

The most prominent aspect of the political economy of land conservation in the United States is capitalist democracy. Economic constraints in a capitalist democracy are dependent upon strong majority opinion; lack of constraint constitutes laissez faire. In the United States, however, the majority implicitly subscribes to the neoclassical theory of unlimited economic growth. For example, 63% of Americans believe there is no limit to economic growth (Madrick 1995), and there is a powerful triangle of academic, corporate, and political interests working—more or less consciously—to perpetuate that belief (Ehrlich & Ehrlich 1996). Meanwhile, Americans value economic growth as highly as species conservation (Czech & Krausman 1999). The combination of these phenomena—belief in unlimited potential for growth and a high value placed on growth—produces a political economy supportive of economic growth (Czech 2000*b*). The most important implication for conservation land acquisition is that economic growth is likely to continue until the economic carrying capacity of nonconservation lands is breached, putting the pressure of the American political economy upon its conservation lands.

## Relative Merits of Acquisitions

Assuming that the land-acquisition budget is less than that necessary to meet all conservation needs, the relative merit of a conservation acquisition is a function of two variables: the conservation value of the parcel of land and the cost of the acquisition. A property that would prevent the extinction of a species would not merit acquisition if the cost was so high as to prohibit the acquisition of 10 other parcels that would prevent the extinction of 10 other species of equal importance. If, on the other hand, the protection of the single property would prevent the extinction of 10 species, then the relative acquisition merit would be less clear.

This simple observation is all that is required to conclude that a conservation land-acquisition strategy must take into account the costs of acquisition. The easiest costs to assess are the monetary costs, primarily land prices (Ando et al. 1998). Nonmonetary costs, such as negative sociopolitical effects, are much less amenable to quantification and therefore less likely to be included in a conservation land-acquisition strategy. This is not to say that such costs should be ignored, but they usually must be considered on a case-by-case basis rather than systematically.

## Economic Growth, Land Prices, and Land Acquisition

Economic growth is a function of growing population and per capita consumption, both of which cause land scarcity. Therefore, economic growth has long been known to cause land prices to rise (Cole 1927). Recent claims about an "information economy" expanding inde-

pendently of land and its natural capital notwithstanding, all economic sectors require the liquidation of natural capital because of the trophic structure of human economy (Czech 2000*b*). The lowest economic trophic level consists of agricultural and extractive sectors. Upon this foundation rests the manufacturing sectors, from the heaviest (e.g., steel) to the lightest (e.g., computer chips). Interwoven throughout all sectors are a multitude of services such as equipment maintenance, banking, and information provision. As Boulding (1993) has pointed out, the economy is an integrated enterprise that tends to contract and expand in concert.

Surplus produced at the agro-extractive level enables the division of labor and resulting manufacturing sectors (Smith 1976). Additional surpluses lead to the proliferation of services. Value is added to products each step of the way (Mankiw 1992). For example, the value of a unit of iron increases when it is manufactured into an implement and increases further when displayed by a retailer at the appropriate marketplace.

The addition of value associated with economic trophic structure corresponds with a spatial intensification of economic activity. The agro-extractive sectors require the most area per monetary unit of transaction (Cramer & Jensen 1994). Meanwhile, activities performed within the higher trophic levels tend to conglomerate geographically due to the efficiencies of exchange offered by spatial compaction. Indeed, this is the economic explanation for urbanization (Monkkonen 1988). For example, it may take a hectare to produce a family's annual supply of cereal grains, a tenth hectare to mill the grain into cereal, and a hundredth hectare to display the cereal in the marketplace. The grain is typically grown in a rural area and the cereal marketed in an urban area. Milling can occur anywhere but tends to occur in the most efficient location, typically between rural and urban areas.

Because of the simultaneous value adding and spatial compaction of economic activity, price per hectare rises through the economic trophic levels. This is consistent with the observation of Nickerson and Lynch (2001) that land prices increase with the density of employment opportunities, which are also greatest in urban areas. The immediate implications for conservation land acquisition are straightforward: conservation lands are generally most expensive in urban areas and least expensive in rural areas. Exceptions exist, for example, in wealthy economies when demand for aesthetically pleasing rural properties is high. But the generally positive relationship of economic activity and land prices means that, with a limited budget, more land may be acquired with a focus on rural areas (Ando et al. 1998). This is not to say that the relative merits of rural acquisitions are higher than those of urban acquisitions, but it is one piece of a puzzle pointing in that direction.

The long-term implications of urbanization and relative land prices are not so simple and must account for the political economy of the United States and economic globalization. In a capitalist democracy with a goal of economic growth, one implication is that more land will go into economic production. History has also shown that the ratio of rural to urban land will continue to decline as agriculture becomes more efficient (Cramer & Jensen 1994). This trend may ultimately be threatened by a decline in agricultural productivity as a result of erosion and other factors, but as the United States depends increasingly on raw materials from other nations, as with timber and minerals, much of the national economy and landscape may become dominated by manufacturing and services in urban areas. Areas where this process is further along include Japan and Hong Kong (Brown 1995). The relationship between urbanization and species endangerment indicates that, as urban areas proliferate, so will species endangerment (Czech et al. 2000).

Lands for acquisition fall along an economic spectrum from totally undeveloped (e.g., wilderness) to totally developed (e.g., urban core). At this stage of the nation's development, neither extreme is likely to be considered for conservation acquisition, because wilderness tends to already be protected and urban cores tend not to have the ecological integrity sought after. Nevertheless, a long portion of the spectrum is relevant. For example, one may compare the acquisition of a ranch in northern-central Montana (relatively wild) with the acquisition of a beachfront property in southeast Florida (relatively urbanized).

When the level of economic activity is considered in developing a conservation land acquisition strategy, it is logical that one end of the development spectrum, or perhaps an area somewhere along the spectrum, may be identified where the relative merits of acquisition are maximized (Czech et al. 2000). Selecting lands along the entire spectrum would not be strategic unless there was no detectable relationship between stage of development and relative merit. A logical starting point, therefore, is to consider each end of the spectrum in terms of relative merit.

A conservation land-acquisition strategy that prioritizes lands in heavily developed, urbanized areas will result in the acquisition of high-priced lands where species are becoming endangered (Ando et al. 1998). This could be a prudent strategy in the context of a stable economy. Although costs would be high, so would benefits, such as the conservation of endangered species. Such benefits explain why conservation lands have been acquired in urban areas such as Austin, Texas; San Diego, California; and Key West, Florida. There is no indication, however, that the implications of a growing economy have been considered. What follows from the aforementioned principles is that in a growing economy (1) the land area harboring endangered species increases as fragmentation, human disturbance, pollution,

and other threats associated with urbanization proliferate and interact synergistically; (2) the areas where economic growth occurs most rapidly are those where land prices increase most rapidly, species become endangered most rapidly, and survival likelihood declines fastest; and (3) higher operating costs associated with intensive user demands, law enforcement, and boundary maintenance in urban areas will reduce the long-term relative merits of urban acquisitions.

In the context of economic growth, the prudence of a strategy that gives priority to lands in undeveloped, rural areas is indicated by the following characteristics: (1) while fragmentation, human disturbance, pollution, and other threats proliferate, rural areas will generally be affected last and least; (2) the areas where land prices increase least rapidly are the same as those where species become endangered least rapidly and where their survival remains most likely; and (3) lower operating costs in rural areas will tend to increase the long-term relative merits of rural acquisitions. Furthermore, restoration costs are often saved in less developed areas (Scott et al. 1989).

Based on the comparison thus far, the most appropriate conservation land-acquisition strategy in the context of economic growth would give priority to lands in undeveloped rural areas, but any potential relationship of biodiversity to land prices should also be considered. For example, some of the most expensive areas, such as estuarine shorelines along the Gulf of Mexico, are biodiversity hotspots (Dobson et al. 1997), whereas less expensive areas, such as lodgepole pine forests in the northern Rockies, often support relatively little biodiversity. Unfortunately, the relationship of biodiversity to land prices is far from straightforward, as the history of wetlands development exemplifies. Wetland prices were very low for most of American history until the labor and technology became available to develop them and the marginal benefits of drainage gradually exceeded the costs (Vileisis 1997). These wetlands were rich in biodiversity while land prices were low, but their ecological integrity and biodiversity declined as land prices increased. For example, some of the most expensive real estate in the United States is in Washington, D.C., which was once a wetland and now contains scant ecological integrity or native biodiversity.

Furthermore, biodiversity hotspots have typically been identified based on numbers of species (Dobson et al. 1997), which are not equal representatives of biodiversity. Functional genome size, phylogenetic distinctiveness, and molecular clock speed should all be considered in prioritizing species for conservation (Czech & Krausman 1998). Based on these properties, one can argue that it is more important to conserve a large-bodied species such as the grizzly bear by conserving large areas in lodgepole pine (and other) ecosystems than it is to conserve several small-bodied species by conserving a small parcel in a coastal ecosystem. This illustrates why it is much more difficult to quantify conservation benefits than it is to quantify costs, particularly the monetary component of costs.

## Ecological Footprinting and the Spatial Component of Habitat

The case for focusing on undeveloped areas in conservation land acquisition is based on a conventional cost-benefit approach in which the relative merit of an acquisition equals the conservation value of a parcel divided by the parcel's cost. There are, however, two other compelling reasons for prioritizing undeveloped areas. The first is based on the concept of the ecological footprint, which is the collective ecological effect that the economic activities of an area has on other areas (Wackernagel & Rees 1996). An ecological footprint includes pollution and the natural capital liquidation resulting from the area's productive and consumptive activities. The concept of an ecological footprint suggests that, all else being equal (e.g., same amount of biodiversity conserved in situ), larger acquisitions are more valuable than smaller acquisitions because they obviate larger ecological footprints.

Another reason for prioritizing undeveloped areas pertains to the habitat requirements of species. The basic habitat components are food, water, cover, and space (Leopold 1933). One phenomenon that makes the setting of land-acquisition priorities so complex, especially when lands occupied by taxonomically and ecologically distant species are compared, is the fact that species differ tremendously in feeding ecology, water requirements, and cover use. Of the habitat components, the one most conducive to measurement and interspecies comparison is space. The spatial requirements of species differ only in quantity, not in quality—the "quality" of space is a function of food, water, and cover. Space is simple to measure, and the most straightforward way to maximize space via land acquisition is by minimizing price per hectare.

The spatial component of habitat illustrates the merits of an ecologically macroeconomic approach to conservation land acquisition. Because the scale of the human economy is a function of the land base devoted to economic production and expands at the competitive exclusion of wildlife in the aggregate, maximizing conservation land area has the effect of maximizing the habitat component of space for wildlife in the aggregate.

## Economic Growth, Carrying Capacity, and Pressure to Produce

The security of properties should also be considered in the development of a conservation land-acquisition strat-

egy. Most national wildlife refuges, for example, were designated via legislation or executive order and are therefore relatively secure. However, legislation and executive orders to withdraw conservation lands for the sake of economic production are possible and even likely in a capitalist democracy pursuing economic growth. An early precedent was an act of Congress that withdrew over 1400 $km^2$ of the original Yosemite National Park for purposes of timber and mineral production (Sellars 1997). Real estate concessions to economic interests have been even more common among the "multiple-use" public land systems such as the national forests (Hirt 1994). There is little conservation insurance short of a paradigm shift in political economy from the pursuit of economic growth to the pursuit of a steady state economy (Czech & Krausman 2001). The possibility of such a paradigm shift was broached by John Stuart Mill in the nineteenth century (Heilbroner 1992). Herman Daly, former World Bank economist and leading figure in ecological economics, has sparked renewed interest in the topic (e.g., Daly 1973, 1997).

Prior to establishment of a steady state economy, wildlife habitats will continue to be lost as natural capital is reallocated from the economy of nature to the human economy (Czech 2000*a*). Some conservation lands will be more secure than others, however, and may comprise what remains of the conservation estate upon cessation of economic growth.

A key factor affecting the security of real property rights is the degree of title held. In practice, the basic distinction on public conservation lands is between fee-title and easement ownership, although government agencies can also enter into resource conservation agreements with private landowners (Main et al. 1999). I posit that, in a political economy pursuing economic growth, an enforcement conundrum will materialize and the terms of conservation easements will be violated on an expanding geographic scale, eventually resulting in wholesale violation.

Conservation easements have existed in the United States since the 1880s, and the refuge system has used them over broad areas, especially in the northern prairie regions, since the 1960s (Sidle 1981). These easements have typically been purchased through the Migratory Bird Conservation Fund or Land and Water Conservation Fund. Reforms of the U.S. tax code reforms beginning in 1976 created economic incentives that are resulting in a proliferation of easements, most of which are donated to private land trusts (Gustanski 2000). Conservation easements have produced tremendous benefits for biodiversity conservation, but the probability of easement violation increases with the number of landowners removed from the grantor of the easement (National Research Council 1993; Gustanski 2000).

To fully grasp the threats to conservation easements, it is necessary to consider the business cycle, which has a long and storied history of study (Rostow 1990) and remains subject to extensive research and controversy (Gordon 1986). There is, however, virtual consensus that capitalist economies are prone to business cycles running from years to tens of years (Rostow 1990).

Business cycles and economic conditions in general have constantly influenced conservation politics in the United States (Czech 2001). Landowners under economic duress are motivated to employ their lands for the sake of economic production (Lant et al. 1995). During recessions, lawbreaking intensifies, particularly with respect to laws having the effect of limiting income (Box 1987). This may help explain why the violation of wetland conservation easements in North Dakota doubled from the period 1964—1971, a period of general prosperity, to the period 1972—1979, a period of recession coupled with inflation (in addition to the reasons suggested by Sidle [1981]). Of the 986 easements acquired by the USFWS, 126 were violated at least once during the entire study period (Sidle 1981). Especially during an intense and protracted recession, easement enforcement and litigation costs may become prohibitive. Court systems are likely to rule in favor of struggling private landowners, as when local and U.S. district courts during the Great Depression refused to grant injunctive relief to the National Park Service for easement violations along the Natchez Trace and Blue Ridge Parkways (National Research Council 1993).

There are many other potential legal challenges to conservation easements, including "[challenges to] constitutional and statutory authority to acquire partial interests in land, the courts' willingness to honor conservation easements . . . and the status of a conservation easement if the surrounding area changes or if landowners seek to amend the conservation easements' terms" (Beliveau 1993:520). State and federal courts may invoke the doctrine of changed conditions to terminate easements when the purposes for which the easements were established can no longer be fulfilled (Mills 1984; Blackie 1989). For example, when a wetland carrying an easement dries up due to economic development higher in the watershed, the conditions may be sufficiently changed to nullify the easement's purposes. Although the doctrine of changed conditions has not yet been applied to conservation easements by the Supreme Court, the Court has applied the doctrine liberally in cases that facilitated economic growth at the expense of wildlife habitats and tribal rights (Wilkins 1993; Czech 1995, 1996).

Another challenging doctrine is cy pres, which is invoked when the purposes of a land trust cannot be achieved because the trust's circumstances (e.g., solvency) have changed (Mills 1984). An act of Congress could stipulate that cy pres may be applied to federal easements or, if necessary, could create a legal counterpart to cy pres for such purposes. For example, if an

agency were reorganized, disbanded, or provided with a new mission, cy pres or its counterpart could be invoked to terminate easements held theretofore by the agency.

Legislation could also be drafted to divest the United States of some or all conservation easements (Beliveau 1993) in order to clear the landscape of legal imbroglios and facilitate the national goal of economic growth. Congress would find it much easier to divest a "non-possessory interest" (Mayo 2000) than fee-title property. Even if such legislation was litigated and found unconstitutional, the enforceability of easements would suffer a major political setback. This scenario may be speculative, but no more than the expectation that conservation easements are impervious to such assaults. As Mayo (2000:40) observed, "the expectation that a conservation easement will serve its purpose *forever* requires some degree of hubris" (emphasis in original). Indeed a different expectation may already be surfacing. Nickerson and Lynch (2001:350) found that conservation easements did not lower the market value of farmland as much as pricing theory predicted; concluded that "Our best explanation is that landowners and land buyers do not expect land use restrictions imposed by the easement to be binding in the future."

Considering the relative insecurity of conservation easements in the long term, a conservation land-acquisition strategy should make fee-title acquisition a priority over easement acquisition. In portions of the refuge system, where conservation easements currently comprise a large percentage, the strategy should include acquiring remaining property interests.

This is not to say that conservation easements are never appropriate. They constitute one tool to supplement a wide range of others for the sake of ecosystem conservation, and they are especially useful for private land trusts because of the tax incentives for donating conservation easements (Gustanski 2000). My suggestion, however, is that conservation easements may be overused, especially by government agencies in the context of a growing economy. Criteria by which to ascertain the prudence of easement acquisition include percentage of project acreage, observability, and connectivity. A refuge consisting primarily of widely scattered, difficult-to-observe easements would be more vulnerable to easement violation than a refuge consisting primarily of fee-title lands supplemented by a handful of readily observable, contiguous easements (Beliveau 1993).

Local political history is often considered in determining the propriety of easement acquisition but is not a reliable long-term criterion. Purchasers of easement-restricted lands will not have the background and are less likely to have the motivation conducive to observing the terms of easements (Collins 2000).

Making a priority of fee-title acquisition is not necessarily inconsistent with the land-acquisition policy of the refuge system, which is to acquire the "minimum interest necessary" to accomplish the purposes of refuges (USFWS 1982). The key issue is what constitutes "minimum interest." As economic growth proceeds, a high percentage of easements may no longer constitute the minimum interest necessary to accomplish the mission of the refuge system.

## Economic Growth and Coastal Properties

There is increasing theoretical and empirical evidence that global warming has commenced as a result of human economic activity, especially with the advent of a fossil-fueled industrial economy and attendant greenhouse-gas emissions (Peters & Lovejoy 1992). The evidence is strong enough that federal agencies such as the U.S. Environmental Protection Agency have formally accepted global warming as reality (Titus & Narayanan 1995). The Earth's average surface temperature is projected to rise 1.4° C to 5.8° C by 2100 AD, making it warmer than at any time since the evolution of modern humans (Intergovernmental Panel on Climate Change 2001).

The effects of global warming include sea-level rise due to warming ocean temperatures (which decreases the density of water), melting polar ice caps, and melting of the Greenland ice shield. Sea levels rose about 29 cm in the twentieth century along most of the U.S. coast (Titus 1998) and, according to the relatively conservative models of the U.S. Environmental Protection Agency, global warming is most likely to raise sea levels 15 cm by the year 2050 and 34 cm by the year 2100 (Titus & Narayanan 1995). The United Nations predicts a sea level rise of 9–88 cm by 2100 (Intergovernmental Panel on Climate Change 2001). The Nature Conservancy is reconsidering its acquisition and management priorities accordingly (Goodstein 2001), but there is no significant evidence that public land conservation agencies are doing likewise.

Coastal properties of the refuge system tend to be low in elevation because they often comprise coastal marshes, barrier islands, coastal salt ponds, and other biologically diverse and productive ecosystems under tidal influence. Clearly the ecology of such properties is imperiled by even minor increases in sea level. This exigency, in combination with the generally high price of coastal properties, means that the relative merits of many coastal acquisitions has dramatically declined. In addition to elevation, criteria used to ascertain the relative merits of coastal acquisitions should include uphill topography, development, and susceptibility to erosion and subsidence. A parcel with gradual slope, nonsubsiding soils, and considerable undeveloped area uphill holds more potential for conservation than a steeply sloped, subsiding parcel abutting developed uphill areas (Titus 1998). In the former case, coastal ecosystems

may "migrate" in concert with sea-level rise; in the latter the coastal ecosystem is more likely to disappear.

## Conclusion

A conservation land-acquisition strategy is a key feature of biodiversity conservation. Although principles of ecology are essential to formulating a sound land-acquisition strategy, they are no more essential than principles of economics and political science. It is appropriate, given the vast geographic scope of American lands held in trust for citizens present and future, that the sweeping endeavors of ecological economics and political science be melded with conservation biology in a transdisciplinary land-acquisition strategy.

American political economy is characterized by capitalist democracy and the goal of economic growth, yet the implications of economic growth have been largely ignored by public land-conservation agencies. My analysis suggests that (1) relatively inexpensive lands in relatively intact ecosystems should be made a priority for acquisition; (2) fee-title acquisition should be heavily favored over easement acquisition, and (3) low-lying coastal properties should be given less priority. These recommendations contribute to an ecologically macroeconomic approach to conservation land acquisition, and each will become more appropriate as the U.S. and global economies grow.

These recommendations, especially the first one, are consistent with those provided by experienced investigators and practitioners of conservation land acquisition. Upon noting the inevitability of further habitat losses in a growing economy, Scott et al. (1991) concluded that "Thus we face a greater challenge than recovering individual species; [i.e.,] ensuring the integrity of existing natural communities and ecosystems, thereby minimizing the number of critically endangered species in the future . . . . If biodiversity is to be saved, our focus must be on saving functioning ecosystems." Land-acquisition planners at The Nature Conservancy (2000:1.1–1.2) have noted that, "Some of the most significant examples of ways in which our work has changed are: (1) a focus on larger and presumably more functional conservation sites [such as] the roadless blocks of forested habitat in the Northern Appalachians ecoregion; (2) a greater emphasis on representing all communities and ecological systems . . . and a correspondingly lesser emphasis on rarity."

A comprehensive land-acquisition strategy includes many additional concepts and practices from conservation biology, ecological economics, and political economy. Examples include invasive-species ecology, natural-capital valuation, and the role of eminent domain, respectively. However, my three recommendations constitute the framework of a coarse-filter approach to land prioritization, and the cost-per-hectare criterion is perhaps the most useful heuristic available for identifying ecologically economic land-acquisition projects because it accounts for much of the measurable cost of an acquisition while "pointing" toward intact ecosystems. Supplementing conservation-benefit criteria with a cost-per-hectare criterion would also help fulfill the aforementioned mandate of the U.S. National Wildlife Refuge System Improvement Act of 1997 to "contribute to the conservation of the ecosystems of the United States," because ecosystems in areas such as the central plains, the northern Mojave Desert, upstate New York, trans-Pecos Texas, and upland/inland areas in many regions that have heretofore been neglected would tend to be prioritized for acquisition.

My recommendations are especially applicable in the context of economic growth. Even if these recommendations are followed, however, conservation land acquisition cannot be disengaged from fundamental principles of ecology. Due to the tremendous breadth of the human niche, the scale of the human economy expands at the competitive exclusion of wildlife in the aggregate. As long as economic growth is a national goal, conservation lands are not secure. Ultimately, the conservation of biodiversity will require a new political economy predicated on sustainability rather than growth.

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