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Tragedy of Ecosystem Services

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The Tragedy of Ecosystem Services

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Derived from funds of natural capital, ecosystem services contribute greatly to human welfare, yet are rarely traded in markets. Most supporting (e.g., soil formation) and regulating (e.g., water purification, pest regulation) ecosystem services, and some cultural (e.g., aesthetic enrichment) and provisioning (e.g., capture fisheries, fuel wood) ecosystem services are declining because of a complex social trap, the "tragedy of ecosystem services," which results in part from the overconsumption of common-pool resources. Additionally, current economic incentives encourage the development of funds of natural capital on private lands for marketable commodities at the expense of ecosystem services that benefit the public. Such ecosystem services are therefore underprovided. Most critically, property law reinforces these market failures by creating incentives to convert funds of natural capital into marketable goods and by assigning no property rights to ecosystem service benefits. Although there is no one pathway out of this tragedy of ecosystem services, potentially effective remedies lie in the evolution of the common law of property, in the reform of economic incentives, and in the development of ecosystem service districts.

Keywords: common law of property, ecosystem services, market failure, natural capital, tragedy of the commons

Garrett Hardin's essay "The Tragedy of the Commons" catalyzed an ongoing debate about how the functioning of social and economic structures—what Hardin (1968) called "the remorseless working of things"—lay at the heart of environmental degradation and natural resource depletion. In the last 40 years, Hardin's examples of the English village common pasture and world population growth have been critiqued (Dasgupta 1996), and his faulty definition of a "commons" has been corrected (Ostrom 1990). Nevertheless, Hardin's original metaphor remains a potent explanation for overconsumption of some common-pool resources (e.g., the collapse of the Atlantic cod fishery; MEA 2005) and excessive emissions of pollutants into environmental sinks at the global (e.g., greenhouse gases; IPCC 2007) or local and regional (e.g., nutrient runoff; Rabalais 2002) levels. Since 1968, ecological and economic concepts of natural capital and ecosystem services have evolved, modifying and focusing this debate (Daily 1997, Daly and Farley 2003).

Whereas natural resources have been treated largely as a biotic and geologic stock of extractable resources for economic use, the emerging view focuses on ecosystems as a capital fund capable of yielding flows of ecosystem services, defined as "the benefits people obtain either directly or indirectly from ecosystems" (MEA 2005). The term "fund" underscores the concept of ecosystems as a form of natural capital that yields a flow of ecosystem services per unit of time, similar to the way in which a fund of financial capital yields a flow of income or interest. Some authors have termed this flow "natural income" (Daly and Farley 2003). Ecosystem service benefits have been estimated at roughly $33 trillion annually (in 1994 US dollars) across the globe, or about $5000 per capita (Costanza et al. 1997). Erecting effective policy institutions and concrete legal instruments for the sustainable, equitable, and efficient provision of ecosystem services will be no small challenge, as it demands the reversal of deeply rooted economic incentives, established doctrines of private property, and associated institutions.

As influential as Hardin's thesis has become—Costanza and colleagues (2004) used the ISI index to show that it is the most cited paper in ecological economics—it is also flawed; in fact, Hardin described the tragedy of open-access resources, but many resource allocation problems arise in the context of common-pool (not to be confused with common-property) resources. In the literature, the terms "common pool" and

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"common property" are often mistakenly used interchangeably, thus confusing analysis of resource-use problems. For a common-pool resource, it is difficult to deny potential beneficiaries the use of the resource once it has been created by society or by nature; it is therefore "nonexcludable." Common-pool resources have two components: (1) a fund (natural capital) and (2) the flow of benefits it yields (natural income including ecosystem services). When the fund is degraded or destroyed (i.e., depreciates), it endangers not only the quantity and quality of future flows but also the viability of the fund itself.

In contrast, common property refers to a property rights regime that determines rules under which the members of a community may access and use a common-pool resource (e.g., how much of the natural income can be used in any period, how it can be used, and who can access it, as well as the conditions under which the fund itself can be used). In the absence of a socially informed property rights regime for using common-pool resources, they become open-access resources and can be exploited to the point of collapse; this is Hardin's tragedy of the commons.

The distinction between open-access and common-property resources is particularly relevant because the institutional solutions suggested by Hardin—dividing the resource into private property or governmental control of its utilization—omit what can sometimes be the most effective solution for governing common-pool resources—developing the institutional frameworks and social capital for an effective self-governing common-property rights regime (Ostrom 1990, Pretty 2003). Moreover, privatization or increasing governmental control of common-pool resources often exacerbates local poverty or leads to resource mismanagement stemming from bureaucratic detachment from local ecological dynamics (Holling and Meffe 1996). An empirical and normative literature (Ostrom et al. [1999] and Dietz et al. [2003] provide insightful synopses) now describes the key elements of an effective commons and, in some cases, how to establish effective markets in ecosystem services. Fortunately, it is not necessary for all of the elements listed below to be in place for a commons to function effectively:

- There is an appropriate geographical definition of the common-pool resource being governed, from the global atmosphere to small-scale watersheds and grazing, fishing, or hunting grounds.
- There is a scientific capacity to observe and measure changing resource conditions on an ongoing basis.
- Social capital—interpersonal relationships in which trust develops over time—among resource users is strong enough to enforce the rules regarding resource utilization among community members so that free ridership (using the resource without paying for it) is minimized.
- Users develop and support their own rules for resource monitoring and use and thereby view these rules as legitimate and help to enforce them.
- Large-scale institutions such as governments and corporations support and legitimize these rules and institutions.
- Appropriate sanctions for violations and procedures for conflict resolution are established.
- Outsiders can readily be excluded from directly exploiting the resource.
- Outside influences, especially global economic driving forces, are understood, and their influence on the common-pool resource can be managed.
- There is an institutional capacity to adapt rules to changing technological, ecological, social, and economic conditions.
- Governance institutions use a variety of mechanisms (e.g., quotas, time and space restrictions on use, taxes and fees, and tradable permits), are geographically nested, and are somewhat redundant to provide for adaptability and checks and balances.

Clearly, building institutions that contain each of these elements is a steep challenge, one that is rarely fully met, which explains why governing common-pool ecological resources is always a struggle that succeeds or fails in a kaleidoscope of ever-evolving outcomes. In advanced market societies, market and government-based institutions increasingly dominate local forms of social capital (Putnam 2000) to manage services from large-scale ecosystems. In fact, it is in developing countries where approaches to resource use more often incorporate key elements of effective commons (Baland and Platteau 1996); some 400,000 to 500,000 local groups have formed worldwide since the early 1990s for the management of watersheds, irrigation, forestry, integrated pest management, and microfinancing for rural development (Pretty 2003).

What falls short in this rich body of literature is an examination of the dynamics inherent in market and legal institutions for the provision of ecosystem services from privately owned funds of natural capital, especially ecosystems on privately owned lands, as opposed to the consumption of natural capital stocks and utilization of environmental sinks. We suggest a revised thesis to address this need, which we call "the tragedy of ecosystem services" in honor of Hardin's seminal contribution.

The diagnosis: Why ecosystem services are declining

The findings of the Millennium Ecosystem Assessment (MEA 2005) show that marketable services fare better than services

that either are nonmarketable or that derive from natural capital lacking clearly defined property rights. For example, among provisioning services, crops, livestock, and aquaculture fish production are increasing, while capture fisheries (FAO 2004) and other wild foods, fuelwood, genetic resources, valuable natural chemicals, and freshwater are declining. Most regulating services (air quality; regional and local climate; erosion, pest, and natural hazard regulation; water purification; and pollination) are declining, and water and disease regulation are experiencing geographically variable outcomes; only carbon sequestration has been enhanced. This evidence is supported by other studies. For example, agricultural intensification has diminished the ecosystem services provided by agricultural landscapes in Sweden from the 1950s to the 1990s (Bjorklund et al. 1999). In the long run, the loss of supporting and regulating services undermines efforts to meet increasing demands for marketable provisioning services such as food production (Tilman et al. 2002).

A diagnosis explaining why supporting, regulating, and some provisioning and cultural ecosystem services are declining has been implicit in natural resource and environmental economics for decades, and is a central component of the emerging school of ecological economics. The economic distinction between private goods and public goods is essential to this diagnosis.

Private goods, such as barrels of crude oil or bushels of corn, are utilized in a rival manner; once someone has consumed the good, it is not available for another person. Private goods are also excludable; it is possible to prevent those who have not purchased the good from having access to it. In contrast, public goods, such as improvements in air and water quality, are both nonrival and nonexcludable: one person's utilization of the good does not prevent others from also using it, and it is not possible to prevent people from having access to the good once it is provided. Consequently, public goods tend to be underprovided because the producer is unable to take full advantage of their value by charging for them; rather, potential users have free access to them.

For owners of natural capital, ecosystem service provision is a positive externality. An externality exists when the production or consumption activities of one individual or firm positively or negatively affect the consumption or production activities of another individual or firm. In the case of ecosystem services flowing from privately owned land, the landowner receives no compensation for providing the services and has no financial incentive to continue providing them. Hence such services tend to be underprovided. Because of these characteristics, coupled with the significant social value of many public goods, institutions informed by public policies and laws have been developed to assure the provisioning or protection of many public goods (see Kaul et al. 1999).

Except for provisioning services, ecosystem services are also generally nonexcludable; once provided by nature or society, they accrue to all within the affected geographical area. Nonexcludability encourages free riders, who receive ecosystem service benefits without having to purchase them or invest in their long-term availability. Landowners preferentially develop their properties to produce marketable commodities and services (private goods) because they obtain the benefits of doing so and bear only a small share of the opportunity costs associated with the diminishment of ecosystem services. This is true even if the value to society of the sacrificed ecosystem services exceeds the economic gains to the landowner. Floodplains, wetlands, and forests that provide carbon storage, wildlife habitat, pollination, water purification, and flood-control services are drained, cleared, planted to crops, converted to pasture for livestock, harvested for timber, or urbanized.

Unlike the tragedy of open access, which occurs when there is no extant system of property rights regulating access to the resource, resulting in the overconsumption of resources and overutilization of environmental sinks, the "tragedy" of ecosystem services is that they are underprovided (table 1). Under market forces alone, other services that generate positive externalities (e.g., education, medical research, vaccinations) or that are nonexcludable (e.g., most roads) would also be underprovided for similar reasons. The difference is that massive public institutions informed by public policy have been erected to provide these essential public services, however imperfectly, whereas institutions and policies for assuring the continued provisioning of ecosystem services are nascent or even absent.

Recent in-depth analysis of US law and policy concerning ecosystem services has revealed a legal dimension of Hardin's "remorseless working of things," where the common law of property seals the deal because those who had benefited from ecosystem services have no legal recourse when these are lost (Ruhl et al. 2007). In fact, US law has built a carefully constructed wall designed to prevent consideration of ecosystem service benefits from interfering with development of land and, under prior appropriation, water for commodity production. US common law evolved over time to disfavor leaving land in its wild, undeveloped state (Sprankling 1996), meaning owners of lands and the accompanying diversity of ecosystems have little incentive to treat them as a fund of natural capital providing valuable ecosystem services. No counterbalancing doctrines have arisen to enable or require a property owner to protect or enhance the continued flow of essential services from ecosystems on their properties. This is the situation regardless of whether the ecosystem services are utilized locally, regionally, or globally (Ruhl et al. 2007).

The diminishment of ecosystem services is thus the result of a complex "social trap" (after Costanza 1987). The trap and how we envision escaping it proceed in no small measure from our conceptualization of ecosystems and their place in our society. Do we perceive them to be funds of natural capital yielding flows of ecosystem services supporting human welfare and, as such, resources to be managed by institutions and policies distinct from those governing private property? Or do we perceive ecosystems as just another part of the landscape that has been divided up into privately owned parcels

Table 1. Likely outcomes for management of natural capital under various property rights and resource usage regimes.

Property rights regime	Usage regime: Rival or consumptive and excludable	Usage regime: Congestible use of nonexcludable common pool	Usage regime: Nonrival use of nonexcludable common pool
Private property	Potentially efficient level of production (e.g., most goods produced in competitive markets)	Underprovision (e.g., wetland restoration for nutrient removal and carbon sequestration)	Underprovision (e.g., ecological restoration for biodiversity and aesthetic values)
Public property (government property can come in the form of direct land ownership, regulatory authority over public resources, or as a trustee)	Perverse subsidies often lead to overuse (e.g., subsidized mining and grazing on public lands, use of public waters for irrigation, production of timber from national forests)	Common public goods provided by governments (e.g., parks, roads, sewage treatment plants)	Pure public goods provided by governments (e.g., national defense, air quality regulation)
Common property (various sources of rules for access to and use of the resource)	Potentially sustainable levels of consumption (see points above under conditions for a well-functioning commons) (e.g., unitized oil fields since 1933)	Potentially sustainable utilization (see points above e.g., Mongolian pastures, tribal fishing grounds, Maine lobster fishery, fishery management plans)	Generally sustainable use (there are few empirical examples because these resources are open access until they become congestible)
Open-access (*res nullius*)	Unsustainable overconsumption (e.g., rule of capture for fish, wildlife, oil [pre-1933])	Unsustainable overuse (e.g., greenhouse gas accumulation, fertilizer runoff leading to eutrophication	Free and sustainable use (e.g., use of atmospheric oxygen, aesthetic values)

Note: The categories listed under "Usage regime" are commonly accepted points along a continuum of empirical regimes. Examples are given from the natural resources and ecosystem service arena. Markets potentially produce efficient levels of production only in the "private property" regime when usage is rival or consumptive. Examples of sustainable use within an open-access property regime are increasingly rare. Hardin's tragedy of the commons occurs under open-access regimes when usage is rival or congestible, resulting in overconsumption or overuse. The tragedy of ecosystem services occurs when nonrival or nonconsumptive services are underprovided by private-property owners.

whose management and use are determined by their owners? How we answer this question may determine the future viability of essential ecosystem services (MEA 2005).

What the literature currently reports is that a failure to develop common-property institutions often leads to depletion or degradation of funds of natural capital and diminished flows of vital ecosystem services. In a perverse positive externality dynamic, the nonexcludable, public-good nature of supporting, regulating, and some cultural and provisioning ecosystem services leads to their underprovision, and existing public institutions fail to make up the growing gap between what society needs and what is being provided. Property law, the backbone of common law, reinforces these market failures because, in advanced capitalist states, ecosystem services have no legal status; their status as common-pool resources is not recognized. Similarly, those individuals and communities benefiting from ecosystem services have limited legal recourse to assure the continued availability of essential services in adequate and timely amounts to meet their own needs or those of the larger society (Ruhl et al. 2007).

Remedies for the tragedy of ecosystem services

While there is no one pathway out of this social trap, potentially effective remedies lie in (a) the evolution of the common law of property, (b) reforming economic incentives, and (c) the development of ecosystem service districts.

Although common law has evolved doctrines that disfavor ecosystem services, nothing about common law is static. The law of property, in particular, is recognized as always a work in progress, with new knowledge and changed circumstances fueling judicial adjustments to applied principles (Blumm and Ritchie 2005). The root of the problem for ecosystem services has been the law's utilitarian premise that developing natural resources invariably puts land to higher and better uses and maximizes social welfare where both are measured in monetary terms. Yet this has been a distinctly American phenomenon, as 19th-century courts, in pursuit of development-friendly doctrines in a sparsely populated land of surplus natural capital and scarce human capital, departed from British rules of nuisance law and core property principles that were much more cognizant of the interdependence of property owners on a crowded agrarian island (Sprankling 1996).

The science of ecosystem services is demonstrating that the premise behind that movement in American property law is sorely misguided in many—if not most—cases. But there is no reason to believe that the common law moves only in one direction, that we are stuck in 19th-century property law notwithstanding what we have learned about natural capital and ecosystem services. Rather, this is precisely the sort of new knowledge the common law embraces, and several recent judicial decisions from around the United States show that courts, when informed about ecosystem services, are more than willing to revisit previously settled principles. For example, a Rhode Island court recently prevented a developer from filling a marsh area on the ground that the marsh benefits other properties by filtering and cleaning runoff, and a Louisiana court ruled that a freshwater diversion project would further the public trust in navigable water resources by restoring coastal wetlands that mitigate storm surges (as discussed in Ruhl et al. 2007). Hence, although its movement may be slow and will depend on litigants to demonstrate the utilitarian value of natural capital and eco-

system services provided by that capital, there is good reason to believe the common law of property will respond accordingly over time. Indeed, an expanded definition of social welfare that embraces the critical role ecosystem services play in sustaining human welfare will facilitate this process.

Of course, by no means can developments in the common law alone correct the tragedy of ecosystem services. Regulatory policy, which was built in the 1970s primarily around pollution control and endangered species protection, has largely overlooked the value of ecosystem services and thus is in need of reform.

The natural resource, environmental, and ecological economics literature is rich with suggested policy reforms that would internalize negative externalities and reward positive externalities in a manner that would encourage cost-effective provision of ecosystem services. Some of the most pertinent contemporary examples include the following:

- Tradable pollution permits, especially for carbon emissions and sequestration (Tietenberg 2006), to motivate private landowners to store additional carbon on their lands rather than in the atmosphere.

- Switching from crop production–based agricultural subsidies to ecosystem service–based subsidies to increase provision of carbon storage, water purification, soil conservation, and wildlife habitat on private rural land (Brouwer and Lowe 2000).

- Incrementally shifting taxation from income to pollution fees and resource consumption (Bovenberg and van der Ploeg 1998), and reducing or eliminating subsidies for natural resource production and consumption (Myers and Kent 2001), to slow the depreciation of funds of natural capital from which ecosystem service are derived.

- Trading debt relief in developing countries for conservation of ecosystem services with global benefits (e.g., biodiversity, carbon storage; Deacon and Murphy 1997).

- Increased transparency and accountability of private-sector performance in decisions that affect ecosystems (MEA 2005).

Ecosystem service districts, similar to school, fire, and other local service districts, are in their infancy and theoretical designs most likely outnumber actual functioning districts (Heal et al. 2001, Ruhl et al. 2003, 2007). Nevertheless, cases such as New Zealand, where environmental administration was realigned along watershed boundaries, bear careful examination (Pyle et al. 2001). To be effective, a generalizable design for ecosystem service districts would do the following:

- Develop institutional frameworks that promote a shift from single-purpose resource management to more holistic and integrated approaches (Hanna and Slocombe 2007).

- Enjoy the type of power and authority (e.g., regulatory, market-based, incentives, reporting and information requirements, planning requirements, voluntary) and financing mechanisms (e.g., taxes, fees, bonds) generally associated with governments, but also be capable of establishing democratically based legitimacy at local levels.

- Build the institutional capacity (i.e., budget, staff, and expertise) to carry out complex scientific, economic, and social analyses and take responsibility for making policy and regulatory decisions through public, transparent procedures.

Moreover, the nesting of political authority (federal, state or provincial, regional, local) and geographic scale must be coherent. Watershed boundaries are a good candidate for such nesting under state or provincial leadership.

Given the diversity in ecosystem services and the ways in which they benefit people, the political challenge of overcoming the tragedy of ecosystem services lies in bringing these three strategies to bear in the best possible manner for each unique situation.

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References cited

Baland JM, Platteau JP. 1996. Halting Degradation of Natural Resources: Is There a Role for Rural Communities? Rome: Food and Agricultural Organization of the United Nations.

Bjorklund J, Limburg KE, Rydberg T. 1999. Impact of production intensity on the ability of the agricultural landscape to generate ecosystem services: An example from Sweden. Ecological Economics 29: 269–291.

Blumm MC, Ritchie L. 2005. Lucas's unlikely legacy: The rise of background principles as categorical takings defenses. Harvard Environmental Law Review 29: 321–368.

Bovenberg AL, van der Ploeg F. 1998. Tax reform, structural unemployment, and the environment. Scandinavian Journal of Economics 100: 593–610.

Brouwer F, Lowe P, eds. 2000. CAP Regimes and the European Countryside: Prospects for Integration between Agricultural, Regional, and Environmental Policies. Wallingford (United Kingdom): CABI.

Costanza R. 1987. Social traps and environmental policy. BioScience 37: 407–412.

Costanza R, et al. 1997. The value of the world's ecosystem services and natural capital. Nature 387: 253–260.

Costanza R, Stern D, Fisher B, He L, Ma C. 2004. Influential publications in ecological economics: A citation analysis. Ecological Economics 50: 261–292.

Daily GC, ed. 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Washington (DC): Island Press.

Daly HE, Farley J. 2003. Ecological Economics: Principles and Applications. Washington (DC): Island Press.

Dasgupta P. 1996. The economics of the environment. Proceedings of the British Academy 90: 165–221.

Deacon RT, Murphy P. 1997. The structure of an environmental transaction: The debt for nature swap. Land Economics 73: 1–24.

Deitz T, Ostrom E, Stern PC. 2003. The struggle to govern the commons. Science 302: 1907–1912.

[FAO] Food and Agricultural Organization. 2004. State of the World's Fisheries and Aquaculture 2004. Rome: FAO.

Hanna KS, Slocombe DS, eds. 2007. Resource and Environmental Management: Fostering Integration in Concept and Practice. New York: Oxford University Press.

Hardin G. 1968. The tragedy of the commons. Science 162: 1243–1248.

Heal G, Daily GC, Ehrlich PR, Salzman J, Boggs C, Hellman J, Hughes J, Kremen C, Ricketts T. 2001. Protecting natural capital through ecosystem service districts. Stanford Environmental Law Journal 20: 333–364.

Holling CS, Meffe GK. 1996. Command and control and the pathology of natural resources management. Conservation Biology 10: 328–337.

[IPCC] Intergovernmental Panel on Climate Change. 2007. Climate Change 2007: The Physical Basis: Summary for Policymakers. Geneva: IPCC. (9 September 2008; *http://news.bbc.co.uk/1/shared/bsp/hi/pdfs/02_02_07_climatereport.pdf*)

Kaul I, Grunberg I, Stern M, eds. 1999. Global Public Goods: International Cooperation in the 21st Century. New York: Oxford University Press.

[MEA] Millennium Ecosystem Assessment. 2005. Ecosystems and Human Well-being: Synthesis. Washington (DC): Island Press.

Myers N, Kent J. 2001. Perverse Subsidies: How Tax Dollars Can Undercut the Environment and the Economy. Washington (DC): Island Press.

Ostrom E. 1990. Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge (United Kingdom): Cambridge University Press.

Ostrom E, Burger J, Field CF, Norgaard RB, Policansky D. 1999. Revisiting the commons: Local lessons, global challenges. Science 284: 278–282.

Pretty J. 2003. Social capital and the collective management of resources. Science 302: 1912–1914.

Putnam R. 2000. Bowling Alone. New York: Simon and Schuster.

Pyle E, Ward RC, McBride G, Huser B. 2001. Establishing watershed management in law: New Zealand's experience. Journal of the American Water Resources Association 37: 783–793.

Rabalais NN, Turner RE, Scavia D. 2002. Beyond science into policy: Gulf of Mexico hypoxia and the Mississippi River. BioScience 52: 129–142.

Ruhl JB, Lant CL, Loftus T, Kraft SE, Adams J, Duram L. 2003. Proposal for a model state watershed management act. Environmental Law 33: 929–947.

Ruhl JB, Kraft SE, Lant CL. 2007. The Law and Policy of Ecosystem Services. Washington (DC): Island Press.

Sprankling JG. 1996. The antiwilderness bias in American property law. University of Chicago Law Review 63: 519–590.

Tietenberg TH. 2006. Emissions Trading: Principles and Practice. Washington (DC): Resources for the Future Press.

Tilman D, Cassman KG, Matson PA, Naylor R, Polasky S. 2002. Agricultural sustainability and intensive production practices. Nature 418: 671–677.

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