

The following resources related to this article are available online at www.sciencemag.org (this information is current as of January 4, 2010):

Updated information and services, including high-resolution figures, can be found in the online version of this article at:

<http://www.sciencemag.org/cgi/content/full/284/5412/278>

This article **cites 27 articles**, 7 of which can be accessed for free:

<http://www.sciencemag.org/cgi/content/full/284/5412/278#otherarticles>

This article has been **cited by** 158 article(s) on the ISI Web of Science.

This article has been **cited by** 17 articles hosted by HighWire Press; see:

<http://www.sciencemag.org/cgi/content/full/284/5412/278#otherarticles>

This article appears in the following **subject collections**:

Ecology

<http://www.sciencemag.org/cgi/collection/ecology>

Information about obtaining **reprints** of this article or about obtaining **permission to reproduce this article** in whole or in part can be found at:

<http://www.sciencemag.org/about/permissions.dtl>



Revisiting the Commons: Local Lessons, Global Challenges

Elinor Ostrom,¹ Joanna Burger,² Christopher B. Field,³ Richard B. Norgaard,⁴ David Policansky⁵

In a seminal paper, Garrett Hardin argued in 1968 that users of a commons are caught in an inevitable process that leads to the destruction of the resources on which they depend. This article discusses new insights about such problems and the conditions most likely to favor sustainable uses of common-pool resources. Some of the most difficult challenges concern the management of large-scale resources that depend on international cooperation, such as fresh water in international basins or large marine ecosystems. Institutional diversity may be as important as biological diversity for our long-term survival.

Thirty years have passed since Garrett Hardin's influential article "The Tragedy of the Commons" (1). At first, many people agreed with Hardin's metaphor that the users of a commons are caught in an inevitable process that leads to the destruction of the very resource on which they depend. The "rational" user of a commons, Hardin argued, makes demands on a resource until the expected benefits of his or her actions equal the expected costs. Because each user ignores costs imposed on others, individual decisions cumulate to a tragic overuse and the potential destruction of an open-access commons. Hardin's proposed solution was "either socialism or the privatism of free enterprise" (2).

The starkness of Hardin's original statement has been used by many scholars and policy-makers to rationalize central government control of all common-pool resources (3) and to paint a disempowering, pessimistic vision of the human prospect (4). Users are pictured as trapped in a situation they cannot change. Thus, it is argued that solutions must be imposed on users by external authorities. Although tragedies have undoubtedly occurred, it is also obvious that for thousands of years people have self-organized to manage common-pool resources, and users often do devise long-term, sustainable institutions for governing these resources (5–7). It is time for

a reassessment of the generality of the theory that has grown out of Hardin's original paper. Here, we describe the advances in understanding and managing commons problems that have been made since 1968. We also describe research challenges, especially those related to expanding our understanding of global commons problems.

An important lesson from the empirical studies of sustainable resources is that more solutions exist than Hardin proposed. Both government ownership and privatization are themselves subject to failure in some instances. For example, Sneath shows great differences in grassland degradation under a traditional, self-organized group-property regime versus central government management. A satellite image of northern China, Mongolia, and southern Siberia (8) shows marked degradation in the Russian part of the image, whereas the Mongolian half of the image shows much less degradation. In this instance, Mongolia has allowed pastoralists to continue their traditional group-property institutions, which involve large-scale movements between seasonal pastures, while both Russia and China have imposed state-owned agricultural collectives that involve permanent settlements. More recently, the Chinese solution has involved privatization by dividing the "pasture land into individual allocations for each herding household" (8). About three-quarters of the pasture land in the Russian section of this ecological zone has been degraded and more than one-third of the Chinese section has been degraded, while only one-tenth of the Mongolian section has suffered equivalent loss (8, 9). Here, socialism and privatization are both associated with more degradation than resulted from a traditional group-property regime.

Most of the theory and practice of successful management involves resources that are effectively managed by small to relatively

large groups living within a single country, which involve nested institutions at varying scales. These resources continue to be important as sources of sustained biodiversity and human well-being. Some of the most difficult future problems, however, will involve resources that are difficult to manage at the scale of a village, a large watershed, or even a single country. Some of these resources—for example, fresh water in an international basin or large marine ecosystems—become effectively depletable only in an international context (10). Management of these resources depends on the cooperation of appropriate international institutions and national, regional, and local institutions. Resources that are intrinsically difficult to measure or that require measurement with advanced technology, such as stocks of ocean fishes or petroleum reserves, are difficult to manage no matter what the scale of the resource. Others, for example global climate, are largely self-healing in response to a broad range of human actions, until these actions exceed some threshold (11).

Although the number and importance of commons problems at local or regional scales will not decrease, the need for effective approaches to commons problems that are global in scale will certainly increase. Here, we examine this need in the context of an analysis of the nature of common-pool resources and the history of successful and unsuccessful institutions for ensuring fair access and sustained availability to them. Some experience from smaller systems transfers directly to global systems, but global commons introduce a range of new issues, due largely to extreme size and complexity (12).

The Nature of Common-Pool Resources

To better understand common-pool resource problems, we must separate concepts related to resource systems and those concerning property rights. We use the term common-pool resources (CPRs) to refer to resource systems regardless of the property rights involved. CPRs include natural and human-constructed resources in which (i) exclusion of beneficiaries through physical and institutional means is especially costly, and (ii) exploitation by one user reduces resource availability for others (13). These two characteristics—difficulty of exclusion and sub-

¹Center for the Study of Institutions, Population, and Environmental Change and Workshop in Political Theory and Policy Analysis, Indiana University, Bloomington, IN 47408, USA. ²Environmental and Occupational Health Sciences Institute, Rutgers University, 170 Frelinghuysen Road, Piscataway, NJ 08854, USA. ³Carnegie Institution of Washington, Stanford, CA 94305, USA. ⁴Energy and Resources Group, University of California, Berkeley, CA 94720, USA. ⁵National Research Council, Washington, DC 20418, USA.

*To whom correspondence should be addressed. E-mail: ostrom@indiana.edu

tractability—create potential CPR dilemmas in which people following their own short-term interests produce outcomes that are not in anyone’s long-term interest. When resource users interact without the benefit of effective rules limiting access and defining rights and duties, substantial free-riding in two forms is likely: overuse without concern for the negative effects on others, and a lack of contributed resources for maintaining and improving the CPR itself.

CPRs have traditionally included terrestrial and marine ecosystems that are simultaneously viewed as depletable and renewable. Characteristic of many resources is that use by one reduces the quantity or quality available to others, and that use by others adds negative attributes to a resource. CPRs include earth-system components (such as groundwater basins or the atmosphere) as well as products of civilization (such as irrigation systems or the World Wide Web).

Characteristics of CPRs affect the problems of devising governance regimes. These attributes include the size and carrying capacity of the resource system, the measurability of the resource, the temporal and spatial availability of resource flows, the amount of storage in the system, whether resources move (like water, wildlife, and most fish) or are stationary (like trees and medicinal plants), how fast resources regenerate, and how various harvesting technologies affect patterns of regeneration (14). It is relatively easy to estimate the number and size of trees in a forest and allocate their use accordingly, but it is much more difficult to assess migratory fish stocks and available irrigation water in a system without storage capacity. Technology can help to inform decisions by improving the identification and monitoring of resources, but it is not a substitute for decision-making. On the other hand, major technological advances in assessing groundwater storage capacity, supply, and associated pollution have allowed more effective management of these resources (15). Specific resource systems in particular locations often include several types of CPRs and public goods with different spatial and temporal scales, differing degrees of uncertainty, and complex interactions among them (16).

Institutions for Governing and Managing Common-Pool Resources

Solving CPR problems involves two distinct elements: restricting access and creating incentives (usually by assigning individual rights to, or shares of, the resource) for users to invest in the resource instead of overexploiting it. Both changes are needed. For example, access to the north Pacific halibut fishery was not restricted before the recent introduction of individual transferable quotas and catch limits protected the resource for

decades. But the enormous competition to catch a large share of the resource before others did resulted in economic waste, danger to the fishers, and reduced quality of fish to consumers. Limiting access alone can fail if the resource users compete for shares, and the resource can become depleted unless incentives or regulations prevent overexploitation (17, 18).

Four broad types of property rights have evolved or are designed in relation to CPRs (Table 1). When valuable CPRs are left to an open-access regime, degradation and potential destruction are the result. The proposition that resource users cannot themselves change from no property rights (open access) to group or individual property, however, can be strongly rejected on the basis of evidence: Resource users through the ages have done just that (5–7, 13, 15, 19). Both group-property and individual-property regimes are used to manage resources that grant individuals varying rights to access and use of a resource. The primary difference between group property and individual property is the ease with which individual owners can buy or sell a share of a resource. Government property involves ownership by a national, regional, or local public agency that can forbid or allow use by individuals. Empirical studies show that no single type of property regime works efficiently, fairly, and sustainably in relation to all CPRs. CPR problems continue to exist in many regulated settings (17). It is possible, however, to identify design principles associated with robust institutions that have successfully governed CPRs for generations (19).

The Evolution of Norms and Design of Rules

The prediction that resource users are led inevitably to destroy CPRs is based on a model that assumes all individuals are selfish, norm-free, and maximizers of short-run results. This model explains why market institutions facilitate an efficient allocation of private goods and services, and it is strongly supported by empirical data from open, competitive markets in industrial societies (20). However, predictions based on this model are not supported in field research or in laboratory experiments in which individuals face a public good or CPR problem and are able to communicate, sanction one another, or make new rules (21). Humans adopt a narrow, self-

interested perspective in many settings, but can also use reciprocity to overcome social dilemmas (22). Users of a CPR include (i) those who always behave in a narrow, self-interested way and never cooperate in dilemma situations (free-riders); (ii) those who are unwilling to cooperate with others unless assured that they will not be exploited by free-riders; (iii) those who are willing to initiate reciprocal cooperation in the hopes that others will return their trust; and (iv) perhaps a few genuine altruists who always try to achieve higher returns for a group.

Whether norms to cope with CPR dilemmas evolve without extensive, self-conscious design depends on the relative proportion of these behavioral types in a particular setting. Reciprocal cooperation can be established, sustain itself, and even grow if the proportion of those who always act in a narrow, self-interested manner is initially not too high (23). When interactions enable those who use reciprocity to gain a reputation for trustworthiness, others will be willing to cooperate with them to overcome CPR dilemmas, which leads to increased gains for themselves and their offspring (24). Thus, groups of people who can identify one another are more likely than groups of strangers to draw on trust, reciprocity, and reputation to develop norms that limit use. In earlier times, this restricted the size of groups who relied primarily upon evolved and shared norms. Citizen-band radios, tracking devices, the Internet, geographic information systems, and other aspects of modern technology and the news media now enable large groups to monitor one another’s behavior and coordinate activities in order to solve CPR problems.

Evolved norms, however, are not always sufficient to prevent overexploitation. Participants or external authorities must deliberately devise (and then monitor and enforce) rules that limit who can use a CPR, specify how much and when that use will be allowed, create and finance formal monitoring arrangements, and establish sanctions for non-conformance. Whether the users themselves are able to overcome the higher level dilemmas they face in bearing the cost of designing, testing, and modifying governance systems depends on the benefits they perceive to result from a change as well as the expected costs of negotiating, monitoring, and enforcing these rules (25). Perceived benefits are

Table 1. Types of property-rights systems used to regulate common-pool resources (7).

Property rights	Characteristics
Open access	Absence of enforced property rights
Group property	Resource rights held by a group of users who can exclude others
Individual property	Resource rights held by individuals (or firms) who can exclude others
Government property	Resource rights held by a government that can regulate or subsidize use

greater when the resource reliably generates valuable products for the users. Users need some autonomy to make and enforce their own rules, and they must highly value the future sustainability of the resource. Perceived costs are higher when the resource is large and complex, users lack a common understanding of resource dynamics, and users have substantially diverse interests (26).

The farmer-managed irrigation systems of Nepal are examples of well-managed CPRs that rely on strong, locally crafted rules as well as evolved norms (27). Because the rules and norms that make an irrigation system operate well are not visible to external observers, efforts by well-meaning donors to replace primitive, farmer-constructed systems with newly constructed, government-owned systems have reduced rather than improved performance (28). Government-owned systems are built with concrete and steel headworks, in contrast to the simple mud, stone, and trees used by the farmers (Fig. 1). However, the cropping intensity achieved by farmer-managed systems is significantly higher than on government systems (Table 2). In a regression model of system performance, controlling for the size of the system, the slope of the terrain, variation in farmer income, and the presence of alter-

native sources of water, both government ownership and the presence of modern headworks have a negative impact on water delivered to the tail end of a system, hence a negative impact on overall system productivity (27).

Imposing strong limits on resource use raises the question of which community of users is initially defined as having use rights and who is excluded from access to a CPR. The very process of devising methods of exclusion has substantial distributional consequences (29). In some instances, those who have long exercised stewardship over a resource can be excluded. A substantial distributional issue will occur, for example, as regulators identify who will receive rights to emit carbon into the atmosphere. Typically, such rights are assigned to those who have exercised a consistent pattern of use over time. Thus, those who need to use the resource later may be excluded entirely or may have to pay a very large entry cost.

The counterpoint to exclusion is too rapid inclusion of users. When any user group grows rapidly, the resource can be stressed. For example, in the last 10 years the annual sales of personal watercraft (PWCs) have risen in the United States from about 50,000 to more than 150,000 a year. This has placed

a burden on the use of surface water and created conflicts with homeowners, other boaters, fishermen, and naturalists. The rapid rise of PWCs has created a burden on the use of shorelines, contributed to a disproportionate increase in accidents and injuries, and caused disturbances to aquatic natural resources (30). Traditional users of the water surface feel threatened by the invasion of their space by a new, faster, and louder boat that reduces the value of surface waters. In many other settings, when new users arrive through migration, they do not share a similar understanding of how a resource works and what rules and norms are shared by others. Members of the initial community feel threatened and may fail to enforce their own self-restraint, or they may even join the race to use up the resource (31).

Given the substantial differences among CPRs, it is difficult to find effective rules that both match the complex interactions and dynamics of a resource and are perceived by users as legitimate, fair, and effective. At times, disagreements about resource assessment may be strategically used to propose policies that disproportionately benefit some at a cost to others (4). In highly complex systems, finding optimal rules is extremely challenging, if not impossible. But despite such problems, many users have devised their

Fig. 1. The government-owned Chiregad irrigation system (right panel) was constructed in Nepal to replace five farmer-owned irrigation systems whose physical infrastructures were similar to the Kathar farmer-managed irrigation system (left panel). In planning the Chiregad system, designers focused entirely on constructing modern engineering works and not on learning about the rules and norms that had been used in the five earlier systems. Even though the physical capital is markedly better than that possessed by the earlier systems, the Chiregad system has never been able to provide water consistently to more than two of the former villages. Agricultural productivity is lower now than it was under farmer management (37). Not only do the farmers invest heavily in the maintenance of the farmer-owned system on the left, they have devised effective rules related to access and the allocation of benefits and costs. They achieve higher productivity than most government-owned systems with modern infrastructure. [Photographs by G. Shivakoti (left) and E. Ostrom (right)]



own rules and have sustained resources over long periods of time. Allowing parallel self-organized governance regimes to engage in extensive trial-and-error learning does not reduce the probability of error for any one resource, but greatly reduces the probability of disastrous errors for all resources in a region.

Lessons from Local and Regional Common-Pool Resources

The empirical and theoretical research stimulated over the past 30 years by Garrett Hardin's article has shown that tragedies of the commons are real, but not inevitable. Solving the dilemmas of sustainable use is neither easy nor error-free even for local resources. But a scholarly consensus is emerging regarding the conditions most likely to stimulate successful self-organized processes for local and regional CPRs (6, 26, 32). Attributes of resource systems and their users affect the benefits and costs that users perceive. For users to see major benefits, resource conditions must not have deteriorated to such an extent that the resource is useless, nor can the resource be so little used that few advantages result from organizing. Benefits are easier to assess when users have accurate knowledge of external boundaries and internal microenvironments and have reliable and valid indicators of resource conditions. When the flow of resources is relatively predictable, it is also easier to assess how diverse management regimes will affect long-term benefits and costs.

Users who depend on a resource for a major portion of their livelihood, and who have some autonomy to make their own access and harvesting rules, are more likely than others to perceive benefits from their own restrictions, but they need to share an image of how the resource system operates and how their actions affect each other and the resource. Further, users must be interested in the sustainability of the particular resource so that expected joint benefits will outweigh current costs. If users have some initial trust in others to keep promises, low-cost methods of monitoring and sanctioning can be devised. Previous organizational experience and local leadership reduces the users' costs of coming to agreement and finding effective

solutions for a particular environment. In all cases, individuals must overcome their tendency to evaluate their own benefits and costs more intensely than the total benefits and costs for a group. Collective-choice rules affect who is involved in deciding about future rules and how preferences will be aggregated. Thus, these rules affect the breadth of interests represented and involved in making institutional changes, and they affect decisions about which policy instruments are adopted (33).

The Broader Social Setting

Whether people are able to self-organize and manage CPRs also depends on the broader social setting within which they work. National governments can help or hinder local self-organization. "Higher" levels of government can facilitate the assembly of users of a CPR in organizational meetings, provide information that helps identify the problem and possible solutions, and legitimize and help enforce agreements reached by local users. National governments can at times, however, hinder local self-organization by defending rights that lead to overuse or maintaining that the state has ultimate control over resources without actually monitoring and enforcing existing regulations.

Participants are more likely to adopt effective rules in macro-regimes that facilitate their efforts than in regimes that ignore resource problems entirely or that presume that central authorities must make all decisions. If local authority is not formally recognized by larger regimes, it is difficult for users to establish enforceable rules. On the other hand, if rules are imposed by outsiders without consulting local participants, local users may engage in a game of "cops and robbers" with outside authorities. In many countries, two centuries of colonization followed by state-run development policy that affected some CPRs has produced great resistance to externally imposed institutions.

The broader economic setting also affects the level and distribution of gains and costs of organizing the management of CPRs. Expectations of rising resource prices encourage better management, whereas falling, unstable, or uncertain resource prices reduce the incentive to organize and assure future avail-

ability (34). National policy also affects factors such as human migration rates, the flow of capital, technology policy, and hence the range of conditions local institutions must address to work effectively. Finally, local institutions are only rarely able to cope with the ramifications of civil or international war.

Challenges of Global Commons

The lessons from local and regional CPRs are encouraging, yet humanity now faces new challenges to establish global institutions to manage biodiversity, climate change, and other ecosystem services (35). These new challenges will be especially difficult for at least the following reasons.

Scaling-up problem. Having larger numbers of participants in a CPR increases the difficulty of organizing, agreeing on rules, and enforcing rules. Global environmental resources now involve 6 billion inhabitants of the globe. Organization at national and local levels can help, but it can also get in the way of finding solutions.

Cultural diversity challenge. Along with economic globalization, we are in a period of reculturalization. Increasing cultural diversification offers increased hope that the diversity of ways in which people have organized locally around CPRs will not be quickly lost, and that diverse new ways will continue to evolve at the local level. However, cultural diversity can decrease the likelihood of finding shared interests and understandings. The problem of cultural diversity is exacerbated by "north-south" conflicts stemming from economic differences between industrialized and less-industrialized countries.

Complications of interlinked CPRs. Although the links between grassland and forest management are complex, they are not so complex as those between maintaining biodiversity and ameliorating climate change. As we address global issues, we face greater interactions between global systems. Similarly, with increased specialization, people have become more interdependent. Thus, we all share one another's common interests, but in more complex ways than the users of a forest or grassland. While we have become more complexly interrelated, we have also become more "distant" from each other and our environmental problems. From our increasingly specialized understandings and particular points on the globe, it is difficult to comprehend the significance of global CPRs and how we need to work together to govern these resources successfully. And given these complexities, finding fair solutions is even more challenging.

Accelerating rates of change. Previous generations complained that change occurred faster and faster, and the acceleration continues. Population growth, economic develop-

Table 2. Relationship of governance structures and cropping intensities [(27), p. 106]. A crop intensity of 100% means that all land in an irrigation system is put to full use for one season or partial use over multiple seasons, amounting to the same coverage. Similarly, a crop intensity of 200% is full use of all land for two seasons; 300% is full use for three seasons.

Parameter	Farmer-owned systems (N = 97)	Government-owned systems (N = 21)	F	P
Head-end crop intensities	246%	208%	10.51	0.002
Tail-end crop intensities	237%	182%	20.33	0.004

ment, capital and labor mobility, and technological change push us past environmental thresholds before we know it. "Learning by doing" is increasingly difficult, as past lessons are less and less applicable to current problems.

Requirement of unanimous agreement as a collective-choice rule. The basic collective-choice rule for global resource management is voluntary assent to negotiated treaties (36). This allows some national governments to hold out for special privileges before they join others in order to achieve regulation, thus strongly affecting the kinds of resource management policies that can be adopted at this level.

We have only one globe with which to experiment. Historically, people could migrate to other resources if they made a major error in managing a local CPR. Today, we have less leeway for mistakes at the local level, while at the global level there is no place to move.

These new challenges clearly erode the confidence with which we can build from past and current examples of successful management to tackle the CPR problems of the future. Still, the lessons from successful examples of CPR management provide starting points for addressing future challenges. Some of these will be institutional, such as multilevel institutions that build on and complement local and regional institutions to focus on truly global problems. Others will build from improved technology. For example, more accurate long-range weather forecasts could facilitate improvements in irrigation management, or advances in fish tracking could allow more accurate population estimates and harvest management. And broad dissemination of widely believed data could be a major contributor to the trust that is so central to effective CPR management.

In the end, building from the lessons of past successes will require forms of communication, information, and trust that are broad and deep beyond precedent, but not beyond possibility. Protecting institutional diversity related to how diverse peoples cope with CPRs may be as important for our long-run survival as the protection of biological diversity. There is much to learn from successful efforts as well as from failures.

References and Notes

- G. Hardin, *Science* **162**, 1243 (1968).
- , *ibid.* **280**, 682 (1998).
- J. E. M. Arnold, *Managing Forests as Common Property* (FAO Forestry Paper 136, Rome, 1998); D. Feeny, S. Hanna, A. F. McEvoy, *Land Econ.* **72**, 187 (1996); F. Berkes and C. Folke, Eds., *Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience* (Cambridge Univ. Press, New York, 1998); A. C. Finlayson and B. J. McCay, *ibid.*, pp. 311–337; R. Repetto, *Skimming the Water: Rent-seeking and the Performance of Public Irrigation Systems* (Research Report 4, World Resources Institute, Washington, DC, 1986).
- D. Ludwig, R. Hilborn, C. Walters, *Science* **260**, 17 (1993).
- B. J. McCay and J. M. Acheson, *The Question of the Commons: The Culture and Ecology of Communal Resources* (Univ. of Arizona Press, Tucson, AZ, 1987); F. Berkes, D. Feeny, B. J. McCay, J. M. Acheson, *Nature* **340**, 91 (1989); F. Berkes, *Common Property Resources: Ecology and Community-Based Sustainable Development* (Belhaven, London, 1989); D. W. Bromley et al., *Making the Commons Work: Theory, Practice, and Policy* (ICS Press, San Francisco, 1992); S. Y. Tang, *Institutions and Collective Action: Self-Governance in Irrigation* (ICS Press, San Francisco, 1992); E. Pinkerton, Ed., *Co-operative Management of Local Fisheries: New Directions for Improved Management and Community Development* (Univ. of British Columbia Press, Vancouver, Canada, 1989); C. Hess, *Common-Pool Resources and Collective Action: A Bibliography, Vol. 3*, and *Forest Resources and Institutions: A Bibliography* (Workshop in Political Theory and Policy Analysis, Indiana Univ., Bloomington, IN, 1996) (www.indiana.edu/~workshop/wsl/wsl.html).
- R. Wade, *Village Republics: Economic Conditions for Collective Action in South India* (ICS Press, San Francisco, 1994).
- D. Feeny, F. Berkes, B. J. McCay, J. M. Acheson, *Hum. Ecol.* **18**, 1 (1990).
- D. Sneath, *Science* **281**, 1147 (1998).
- C. Humphrey and D. Sneath, Eds., *Culture and Environment in Inner Asia* (White Horse Press, Cambridge, 1996), vol. 1.
- R. Costanza et al., *Science* **281**, 198 (1998).
- W. S. Broecker, *ibid.* **278**, 1582 (1997).
- M. McGinnis and E. Ostrom, in *The International Political Economy and International Institutions*, O. R. Young, Ed. (Elgar, Cheltenham, UK, 1996), vol. 2, pp. 465–493; R. O. Keohane and E. Ostrom, Eds., *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains* (Sage, London, 1995); S. Buck, *The Global Commons: An Introduction* (Island, Washington, DC, 1998).
- E. Ostrom, R. Gardner, J. Walker, *Rules, Games, and Common-Pool Resources* (Univ. of Michigan Press, Ann Arbor, MI, 1994).
- E. Schlager, W. Blomquist, S. Y. Tang, *Land Econ.* **70**, 294 (1994).
- W. Blomquist, *Dividing the Waters: Governing Groundwater in Southern California* (ICS Press, San Francisco, 1992).
- R. Norgaard, *Adv. Hum. Ecol.* **4**, 141 (1995); C. Gibson, *Politicians and Poachers: The Political Economy of Wildlife Policy in Africa* (Cambridge Univ. Press, New York, 1999); A. Agrawal, *Greener Pastures: Politics, Markets, and Community Among a Migrant Pastoral People* (Duke Univ. Press, Durham, NC, 1999).
- Organisation for Economic Co-operation and Development (OECD), *Towards Sustainable Fisheries: Economic Aspects of the Management of Living Marine Resources* (OECD, Paris, 1997); National Research Council, *Sustaining Marine Fisheries* (National Academy Press, Washington, DC, 1999).
- H. S. Gordon, *J. Pol. Econ.* **62**, 124 (1954); B. J. McCay, *Coastal Ocean Manage.* **28**, 3 (1995).
- E. Ostrom, *Governing the Commons: The Evolution of Institutions for Collective Action* (Cambridge Univ. Press, New York, 1990).
- C. R. Plott, *Science* **232**, 732 (1986); K. A. McCabe, S. J. Rassinetti, V. L. Smith, *ibid.* **254**, 534 (1991).
- See S. Bowles, R. Boyd, E. Fehr, H. Gintis, *Homo reciprocans: A Research Initiative on the Origins, Dimensions, and Policy Implications of Reciprocal Fairness* (working paper, University of Massachusetts, 1997); E. Ostrom and J. M. Walker, in *Perspectives on Public Choice: A Handbook*, D. C. Mueller, Ed. (Cambridge Univ. Press, New York, 1997), pp. 35–72; J. M. Orbell, A. van de Kragt, R. M. Dawes, *J. Personality Soc. Psych.* **54**, 811 (1988); E. Ostrom, *Am. Pol. Sci. Rev.* **92**, 1 (1998). In these experiments, the formal structure of a dilemma is converted into a set of decisions made by subjects who are financially rewarded as a result of their own and others' decisions. See also J. H. Kagel and A. E. Roth, Eds., *The Handbook of Experimental Economics* (Princeton Univ. Press, Princeton, NJ, 1995). The model is also not as robust in explaining exchange behavior in traditional societies where evolved norms still strongly affect behavior.
- L. Cosmides and J. Tooby, in *The Adapted Mind: Evolutionary Psychology and the Generation of Culture*, J. H. Barkow, L. Cosmides, J. Tooby, Eds. (Oxford Univ. Press, New York, 1992), pp. 163–228; L. Cosmides and J. Tooby, *Am. Econ. Rev.* **84**, 327 (1994); E. Hoffman, K. McCabe, V. Smith, *ibid.* **86**, 653 (1996).
- R. Axelrod, *The Evolution of Cooperation* (Basic Books, New York, 1984); *Am. Pol. Sci. Rev.* **80**, 1095 (1986).
- M. A. Nowak and K. Sigmund, *Nature* **355**, 250 (1992); D. M. Kreps, P. Milgrom, J. Roberts, R. Wilson, *J. Econ. Theory* **27**, 245 (1982).
- H. Demsetz, *Am. Econ. Rev.* **62**, 347 (1967); D. North, *ibid.* **84**, 359 (1994); C. M. Rose, *Property & Persuasion: Essays on the History, Theory, and Rhetoric of Ownership* (Westview, Boulder, CO, 1994); J. E. Krier, *Harvard J. Law Pub. Policy* **15**, 325 (1992); F. Michelman, in *Liberty, Property, and the Future of Constitutional Development*, E. F. Paul and H. Dickman, Eds. (State Univ. of New York Press, Albany, NY, 1990), pp. 127–171; V. Ostrom, *Brigham Young Univ. Law Rev.* **3**, 857 (1990).
- E. Ostrom, in *The Commons Revisited: An Americas Perspective*, J. Burger, R. B. Norgaard, E. Ostrom, D. Policansky, B. Goldstein, Eds. (Island, Washington, DC, in press).
- W. F. Lam, *Governing Irrigation Systems in Nepal: Institutions, Infrastructure, and Collective Action* (ICS Press, Oakland, CA, 1998).
- , *World Dev.* **24**, 1301 (1996).
- G. D. Libecap, *J. Instl. Theor. Econ.* **145**, 6 (1989).
- J. Burger, *Condor* **100**, 528 (1998); in (26); L. Whiteman, *National Parks* **71**, 22 (1997).
- F. G. Speck and W. S. Hadlock, *Am. Anthropol.* **48**, 355 (1946); C. Safina, *Issues Sci. Technol.* **10**, 37 (1994).
- J.-M. Baland and J.-P. Platteau, *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?* (Clarendon, Oxford, 1996); M. A. McKean, *J. Theor. Pol.* **4**, 247 (1992).
- J. Buchanan and G. Tullock, *The Calculus of Consent* (Univ. of Michigan Press, Ann Arbor, MI, 1962); J. B. Wiener, *Yale Law J.* **108**, 677 (1999).
- C. W. Clark and G. R. Munro, in *Investing in Natural Capital: The Ecological Economics Approach to Sustainability*, A. M. Jansson, M. Hammer, C. Folke, R. Costanza, Eds. (Island, Washington, DC, 1994), pp. 343–361.
- See O. Young, Ed., *Science Plan for Institutional Dimensions of Global Environmental Change* (International Human Dimensions Programme on Global Environmental Change, Bonn, Germany, 1999); *Global Governance: Drawing Insights from the Environmental Experience* (MIT Press, Cambridge, MA, 1997); P. Haars, R. Keohane, M. Levy, *Institutions for the Earth: Sources of Effective Environmental Protection* (MIT Press, Cambridge, MA, 1993).
- J. B. Wiener, *Georgetown Law J.*, in press.
- R. M. Hilton, *J. Theor. Pol.* **4**, 283 (1992).
- This paper profited from ideas discussed at a symposium on "The Commons Revisited: An Americas Perspective" held in conjunction with the X General Assembly of the Scientific Committee on Problems of the Environment (SCOPE), June 1998. We thank the U.S. Environmental Protection Agency, NSF, and NASA for supporting the U.S. National Committee for SCOPE, where this effort began. We thank F. Berkes, A. Blomquist, P. Dalecki, D. Dodds, K. Dougherty, D. Feeny, T. Hargis-Young, C. Hess, B. J. McCay, M. McGinnis, M. Polski, E. Schlager, N. Sengupta, J. Unruh, O. Young, and anonymous reviewers for their useful comments. Supported by NSF grant SBR-9521918, the U.N. Food and Agriculture Organization (FAO), the Ford Foundation, and the MacArthur Foundation (E.O.) and by U.S. Department of Energy grant AI DE-FC01-95EW55084 to the Consortium for Risk Evaluation with Stakeholder Participation and National Institute of Environmental Health Sciences grant ESO 5022 (J.B.).