

## The Tragedy of the Commons: Twenty-Two Years Later

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*Hardin's Tragedy of the Commons model predicts the eventual overexploitation or degradation of all resources used in common. Given this unambiguous prediction, a surprising number of cases exist in which users have been able to restrict access to the resource and establish rules among themselves for its sustainable use. To assess the evidence, we first define common-property resources and present a taxonomy of property-rights regimes in which such resources may be held. Evidence accumulated over the last twenty-two years indicates that private, state, and communal property are all potentially viable resource management options. A more complete theory than Hardin's should incorporate institutional arrangements and cultural factors to provide for better analysis and prediction.*

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It was twenty years ago today; Sgt. Pepper taught the band to play (John Lennon and Paul McCartney (1967). *Sgt. Pepper's Lonely Hearts Club Band*. Northern Songs Ltd.).

### INTRODUCTION

Garrett Hardin's *The Tragedy of the Commons* was published 22 years ago (Hardin, 1968). Although it focused attention on overpopulation, the

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dominant legacy of the paper has been its metaphor of common-property resource management. In the intervening years, the ideas that Hardin popularized have become the most widely accepted explanation for overexploitation of resources that are commonly held. The essential idea was that resources held in common, such as oceans, rivers, air, and parklands, are subject to massive degradation. Hardin was neither alone nor novel in making the argument. He noted that Lloyd had made the same point in a series of lectures in the 1830's (Lloyd, 1968). Two modern resource economists, Gordon (1954) and Scott (1955), are usually credited with the first statement of the conventional theory of the commons, although Hardin does not mention them. In this paper, we examine the accumulated evidence pertaining to common-property resource management and provide a critique of the conventional theory expounded by Hardin.

Although Hardin was referring to global concepts such as carrying capacity, his observations about resources held in common are considered by many as the definitive insight. To make his points about the need for major social change to deal with problems such as overpopulation, resource depletion, and air and water pollution, Hardin (1968) relied upon a thought experiment. He asked the reader to imagine what would happen to a metaphorical village commons if each herder were to add a few animals to his herd. His metaphor highlighted the divergence between individual and collective rationality. If each herdsman found it more profitable to graze more animals than the pasture could support, because each took all the profit from an extra animal but bore only a fraction of the cost of overgrazing, the result would be a tragic loss of the resource for the entire community of herders. Thus Hardin concluded that "freedom in the commons brings ruin to all" (Hardin, 1968, p. 1244).

This conclusion has been accorded by some the status of scientific law. The tragedy of the commons has become part of the conventional wisdom in environmental studies, resource science and policy, economics, ecology, and political science (McEvoy, 1988, p. 214) and is featured in textbooks (Nebel, 1987, pp. 484-485; Lineberry, 1983, pp. 579-580). J. A. Moore, author of a major environmental education project for the American Society of Zoologists, states: "Hardin's Tragedy of the Commons should be required reading for all students ... and if I had my way, for all human beings" (Moore, 1985, p. 602). It has also been used in formulating resource-management policy, as recently shown for Atlantic Canada fisheries (Matthews, 1988).

To avoid the tragedy, Hardin (1968; Hardin and Baden, 1977) concluded that the commons could be privatized or kept as public property to which rights to entry and use could be allocated. Hardin has been widely cited as having said that resource degradation was inevitable unless common property was converted to private property, or government regulation of uses and users

was instituted. In a later paper, Hardin (1978) specifically recognized two general solutions, and presumably no others: private enterprise and socialism (control by government). Hardin argued that if we do not act in one of these two ways, we “acquiesce in the destruction of the commons” (Hardin, 1968, p. 1245).

We examine the evidence on factors associated with successful vs. unsuccessful exploitation of common-property resources, focusing in particular on communally-held resources. Surprisingly little careful empirical work on common property followed Hardin’s seminal publication. However, several recent volumes summarize a growing and rich body of evidence relevant to common-property resource management (National Research Council, 1986; McEvoy, 1986, 1988; Marchak *et al.*, 1987; McCay and Acheson, 1987; Wade, 1987; Fortmann and Bruce, 1988; Pinkerton, 1989; Berkes, 1989; Cordell, 1989; Ostrom, forthcoming). A few definitions will be presented before examining this new evidence in the light of the predictions of Hardin’s model.

## DEFINITIONS AND CONCEPTS

Common-property resources include fisheries, wildlife, surface and groundwater, range, and forests. It is important to delineate the characteristics shared by these resources, and to distinguish between the resource and the property-rights regime in which the resource is held (National Research Council, 1986).

Common-property resources share two important characteristics. The first is excludability (or control of access). That is, the physical nature of the resource is such that controlling access by potential users may be costly and, in the extreme, virtually impossible. Migratory resources such as fish, wildlife, and groundwater pose obvious problems for regulating access. Similarly, range and forest lands typically pose problems of exclusion. For large bodies of water, the global atmosphere, and radio frequency bands, exclusion is even more problematic.

The second basic characteristic of common-property resources is subtractability, that is, each user is capable of subtracting from the welfare of other users. Even if users cooperate to enhance the productivity of their resource, for instance by replanting trees, the nature of the resource is such that the level of exploitation by one user adversely affects the ability of another user to exploit the resource. Subtractability (or rivalry) is the source of the potential divergence between individual and collective rationality. If one user pumps more water from an aquifer, other users will experience an increase in pumping costs as aggregate use approaches or exceeds recharge

capacity. If one user harvests fish, the catch per unit of fishing effort of other fishermen declines. Hence, we define common-property resources as *a class of resources for which exclusion is difficult and joint use involves subtractability* (Berkes *et al.*, 1989, p. 91).

The definition here resembles one given by Elinor Ostrom (1986, p. 604; see also Fortmann and Bruce, 1988, p. 2). Ostrom underscores the importance of the distinction between the intrinsic nature of the resource and the property-rights regime under which it is held, by defining the class of resources as "common-pool resources." Because of the widespread use of the term common property for certain kinds of resources, we have chosen to use this term to refer to the *resource* and the term communal property to refer to one of the four basic property-rights *regimes*.

In order to facilitate analysis, we define four categories of property rights within which common-property resources are held: open access, private property, communal property, and state property. These are ideal, analytic types. In practice, many resources are held in overlapping, and sometimes conflicting combinations of these regimes, and there is variation within each. It is nevertheless important to distinguish these four basic property-rights regimes (Ciriacy-Wantrup and Bishop, 1975; for similar distinctions see also Berkes *et al.*, 1989, p. 91; Bromley, 1986, 1989b, pp. 872-875; Bromley and Cernea, 1989, pp. 3-5; Demsetz, 1967, p. 354; Gibbs and Bromley, 1989, pp. 24-27; Godwin and Shepard, 1979, p. 267; Jacobs and Munro, 1987, p. 442; Libecap, 1986, p. 33; Marchak, 1987, pp. 4-5; Ostrom, 1986).

*Open access* is the absence of well-defined property rights. Access to the resource is unregulated and is free and open to everyone. Many offshore ocean fisheries before the twentieth century, or the global atmosphere provide examples.

Under *private property*, the rights to exclude others from using the resource and to regulate the use of the resource are vested in an individual (or group of individuals such as a corporation). Private-property rights are generally recognized and enforced by the state. Unlike rights under open access, private-property rights usually are exclusive and transferable (Regier and Grima, 1985). Examples include forests and rangelands that are held privately.

Under *communal property*, the resource is held by an identifiable community of interdependent users. These users exclude outsiders while regulating use by members of the local community. Within the community, rights to the resource are unlikely to be either exclusive or transferable; they are often rights of equal access and use. Some inshore fisheries, shellfish beds, range lands, and forests have been managed as communal property; similarly, water-users associations for many groundwater and irrigation systems can be included in this category. The rights of the group may be legally recog-

nized. In other cases the rights are *de facto*, depending on the benign neglect of the state. Some scholars use the term common property, or simply a common, to refer exclusively to the regime we classify as communal property (Ostrom, 1986; Bromley, 1986, 1989a,b; Marchak, 1988-1989; Blaikie and Brookfield, 1987, pp. 186-187).

Finally, under *state property*, or state governance, rights to the resource are vested exclusively in government which in turn makes decisions concerning access to the resource and the level and nature of exploitation. Examples include forests and rangelands held by the government or crown-owned, and resources such as fish and wildlife that may be held in public trust for the citizenry. The category of state property may refer to property to which the general public has equal access and use rights such as highways and public parks. The nature of the state property regime also differs from the other regimes in that, in general, the state, unlike private parties, has coercive powers of enforcement.

Although the nature of the property-rights regime under which the resource is held is important, that information is not sufficient to draw valid conclusions concerning behavior and outcomes. One theme of the paper is that one must understand a whole host of institutional arrangements governing access to and use of the resource. Knowledge of the property rights is necessary but not sufficient. Many of the misunderstandings found in the literature may be traced to the assumption that common property is the same as open access. Hardin's prediction of the inevitability of over-exploitation follows from this assumption. Yet the assumption is inaccurate and it has led to a great deal of confusion. Based on our definition of common property, an approach to testing Hardin's hypothesis is to examine two broad challenges in the management of common-property resources: (1) the exclusion of other potential users, and (2) the regulation of use and users to ameliorate the problems associated with subtractability. Evidence on each will be examined for each of the property-rights regimes listed above.

In evaluating evidence to test Hardin's hypothesis, a criterion with which to classify the outcome as a success or failure is needed. The choice of any particular standard is arbitrary, but we will use *ecological sustainability* as the working criterion of success, that is, whether the resource in question has been used "without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 8). Sustainability is a rough index of management success; it does not necessarily imply that resource utilization is optimal from either ecological or economic points of view (see World Conservation Strategy, 1980). Note that the criterion of sustainability is both human, and resource-centric regarding the source of valuation, not exclusively one or the other.

## EVIDENCE ON EXCLUSION

*Open Access.* The evidence supports Hardin's argument concerning degradation due to the inability to regulate access to resources held as open access. Examples are many, and include the classic case of the historical depletion of various whale stocks in the open ocean. Several examples, however, reveal a point not mentioned by Hardin. In many cases, the tragedy occurred only after open-access conditions were created, often as a consequence of the destruction of existing communal land-tenure and marine-tenure systems. A number of these cases involved the imposition of colonial rule, as in sub-Saharan Africa (Johnson and Anderson, 1988), the Pacific Islands (Johannes, 1978), and northwest North American salmon rivers (Berkes, 1985, and references therein).

*Private Property.* The establishment and enforcement of private property rights have frequently provided the institutional arrangements for successful exclusion. Private-property rights may not, however, be sufficiently precise for solving the exclusion problem. A classic example is the exploitation of oil pools in much of the United States. In an 1889 Pennsylvania Supreme Court decision, the doctrine of law of capture was applied to oil. Private property rights in oil were assigned only upon extraction. In practice, this means that each owner of surface rights has the incentive to accelerate their pumping of oil to the surface. The result is a duplication of drilling and other capital costs, substantial reduction in the overall rate of recovery, and dissipation of economic rents. A remedy to the problem has long been recognized—to define property rights in the underground pool as a unit (unitization) before extraction rather than after. In jurisdictions (such as Wyoming) in which unitization is required before drilling on land leased for oil exploration, greater efficiency has been achieved. In spite of the potential gains for all users through unitization, this form of contract is uncommon in other jurisdictions (such as Texas and Oklahoma) because the high cost of private contracting inhibits its adoption. Private property rights and the incentives they afford are not always sufficient to achieve efficient exploitation (Libecap and Wiggins, 1985; Wiggins and Libecap, 1985).

There is an enforcement problem with all types of property rights, including private property. For common-property resources, which by definition pose exclusion problems, such enforcement can be costly. Well recognized *de jure* rights of the medieval lord, and even contemporary landlords, to fish and game have been routinely violated by poachers (McCay, 1987; Thompson, 1975). The extent to which the community regards private-property rights as legitimate affects the cost of enforcement. The difficulty of enforcing private claims to common-property resources is exacerbated by competing claims to communal rights in those resources. This is evident in the United States

oyster industry, where a private property regime, including leasehold, is not politically acceptable in many areas (McCay, 1987) regardless of the fact that it is logical, feasible, and demonstrably more efficient (Agnello and Donnelley, 1984).

*Communal Property.* Hardin did not consider the possibility of exclusion under communal-property regimes. By exclusion we mean the power to exclude people other than members of a defined community. Evidence suggests that successful exclusion under communal property is the rule rather than the exception. Well-documented contemporary cases include Amerindian community hunting and fishing lands in James Bay, eastern subarctic Canada (Berkes, 1977, 1987; Feit, 1987). Here, the communal-property regime collapsed as a result of incursions by outsiders and recovered with the re-establishment of exclusion at least twice since the nineteenth century (Feit, 1986). Other examples come from the Pacific islands where communal-property regimes have collapsed in some areas but continue to be viable in many others (Johannes, 1978, 1982; Ruddle and Akimichi, 1984; Ruddle and Johannes, 1985).

Communal property is not confined to remote and sparsely populated areas. Cooperative-based coastal fisheries in Japan provide many successful examples of communal-property systems. These fishing communities hold legally guaranteed exclusive fishing rights in coastal areas (Ruddle, 1987, 1989). One of the major conclusions of the National Research Council conference (1986, p. 621) was that legal recognition of communal rights, as in Japanese coastal fisheries, was crucial for the success of communal-property regimes. Many of the island nation states in the Pacific are creating formal legal guarantees of traditional communal-property rights (Ruddle and Johannes, 1985; Baines, 1989). Even when there is no legal recognition of communal property, the exclusion of outsiders by local users through such means as threats and surreptitious violence is not uncommon (Acheson, 1975; McEvoy, 1988). The persistence of community-based lobster fishing territories in Maine is merely one example, but an important one because it occurs in a country and culture in which the belief in right of free access is deeply held (Acheson, 1987, 1988).

The examples given thus far are for fish and wildlife for which exclusion is particularly difficult because of the migratory nature of the resource. Successful exclusion can also be found for other resource types, including grazing lands, forests, and water resources (National Research Council, 1986; Fortmann and Bruce, 1988; Dani, *et al.*, 1987; Maass and Anderson, 1978).

Pressure on the resource because of human population growth, technological change, or economic change, including new market opportunities, may contribute to the breakdown of communal-property mechanisms for exclusion. The role of population growth is especially controversial. For ex-

ample, some argue that in the case of East Africa, the carrying capacity of rangelands under any management regime has been exceeded (Talbot, 1986). Other cases indicate that population is merely one of many interrelated social and economic problems (Jodha, 1985; Johnson and Anderson, 1988; Peters, 1987; Fortmann and Roe, 1986).

Communal-property regimes fail to provide for exclusion for other reasons as well. Many of these failures are associated with the appropriation of the resource by politically or militarily powerful groups, or by other factors such as land reform that disrupt existing communal management systems (Jodha, 1987). Others are associated with problems of scale and internal organization. The social and political characteristics of the users of the resource and how they relate to the larger political system affect the ability of local groups to organize and manage communal property (Ostrom, 1987, 1988, forthcoming).

*State Property.* Exclusive state governance of the resource has in many cases been sufficient to provide for adequate exclusion. However, difficulties in exclusion are not necessarily overcome by declaring the resource to be state property. A vivid example comes from Nepal. Alarmed by deforestation, the government nationalized forests in 1957, converting what were often communal forests into *de jure* state property. But the result more closely approximated the creation of *de facto* open access. Villagers whose control of nearby forests had been removed often succumbed to the incentives of law of capture. Deforestation accelerated instead of decelerated. In the face of worsening conditions the government began to experiment in 1976 with the re-creation of communal-property rights (Arnold and Campbell, 1986; Bromley and Chapagain, 1984).

Similar evidence on exclusion is found in the management of state forests in Niger and Thailand. In both countries state property has often been treated as open access. In response to the growing crisis of degradation in Niger, some farmers began in the 1980's to extend their private property rights in arable land to include the trees, which are *de jure* state property (Thomson *et al.*, 1986, 1989; Feeny, 1988a).

Another problem with state governance is that imperfections in the political process will often be mirrored in resource management (McEvoy, 1988). In some cultures, free access to certain resources for citizens at large is viewed as a right. In other cases, the state is especially responsive to the interests of the elite (Feeny, 1982, 1988b; Jodha, 1985). Some instances of apparent tragedies of the commons are more accurately construed as examples of government failure (Anderson, 1987; Marchak, 1988-1989).

The logic of the argument of *The Tragedy of the Commons* is that we should not observe sustainable management of common-property resources and the exclusion of some uses or users, under regimes other than private

or state property. But as we have illustrated, exclusion is feasible, if not always successful, under private, state, *and* communal-property regimes. Furthermore, private or state ownership is not always sufficient to provide for exclusion.

## EVIDENCE ON REGULATIONS OF USE AND USERS

*Open Access.* Hardin's predictions that incentives for successful resource management are absent from or weak in open access regimes are in general consistent with the evidence. In such regimes, under conditions in which demand exceeds the capacity of the resource to sustain itself, and where the technology is available to exploit the resource at a high level, many species, including the North American passenger pigeon and the bison, have become extinct, or virtually extinct. In the context of the day, free and unregulated use of resources such as the bison initially made sense. To illustrate the individual rationality that lay behind ecological tragedy, Hardin (1978) invokes the image of Kit Carson shooting bison on the plains, taking only the tongue and leaving the rest. This is not economically irrational if one considers that the game was then abundant but the hunter's time was scarce. Depletion occurred rapidly, before countervailing institutional arrangements or changing cultural values could prevent it.

*Private Property.* Privatization usually provides incentives for rational exploitation of the resource. If the owner has property rights in the resource and those rights are tradeable, both the costs and benefits will accrue to the same owner and will be reflected in the market price of the resource, giving the owner the pecuniary incentive to refrain from destructive use. These incentives, however, are not necessarily consistent with sustainable use. Suppose a redwood planted for \$1 is worth \$14,000 at maturity—which may take 2000 years. The implied rate of return would be less than 0.5%, well below the rates of return generally available to investors. Although planting a redwood may make ecological sense, it does not make economic sense under a private-property regime (Hardin, 1979).

More realistically, Clark (1973) has shown that for relatively slow-growing and late-maturing species such as whales, it may be economically optimal to deplete the resource rather than to use it sustainably. For the Antarctic blue whale with a maximum sustainable yield level of probably no more than 5% a human-rate of time preference (discount rate) of greater than this 5% would be sufficient to lead to its extinction, even under exclusive and enforceable private-property rights. These rights permit the owner to maximize the present value of the resource, yet the resource is not protected from extinction.

*Communal Property.* There is abundant evidence, contrary to Hardin, on the ability of social groups to design, utilize, and adapt often ingenious mechanisms to allocate use rights among members. The medieval English commons featured in Hardin's paper, like many other historic and contemporary commons, were often subject to comprehensive systems of regulation. For example, stinting was often practiced, that is, limiting the number of head that each owner could graze. Not only was access exclusive to certain members of the village, but their rights were often closely regulated (McCloskey, 1976; Cox, 1985; Campbell and Godoy, 1986; Dahlman, 1980; Fenoaltea, 1988). A plethora of scholars have noted in passing that the commons operated successfully for several hundred years in medieval England, and have questioned if a tragedy of the sort described by Hardin (1968) ever occurred widely (Schumacher, 1979, p. 139; Repetto, 1985, p. 145; Potter, 1974, p. 813; Dasgupta, 1983, p. 13; Marchak, 1988-89, p. 9).

Forest and meadow commons in Japanese villages were also the subject of elaborate regulations. Village leaders set opening and closing dates for the harvest of certain products. In some villages, thatch was harvested collectively; bundles were then randomly assigned to each household. This device permitted the aggregate level of utilization to be controlled while giving each household an incentive to be reasonably conscientious in its harvesting effort. Guards patrolled the common lands to prevent poaching both by villagers and outsiders. Written rules provided a graduated schedule of fines for violators. Harvesting tools were also regulated. Regulations legislated by villagers ensured sustainable use of common lands for generations (McKean, 1982, 1986).

In the Japanese case, forest and meadow lands and irrigation works were held as communal property while crop lands were held privately. This is not an isolated example of the co-existence of two property-rights regimes. There are other cases indicating the ability of users to match appropriately the resource with the regime (Netting, 1976). In some societies, the same resource may alternate back and forth between communal and private control seasonally or over the long term (Bauer, 1987; Vondal, 1987; Acheson, 1989b; Wade, 1986, 1987).

Not all examples of successful regulation are historic or based on long-standing tradition. In a study of Turkish coastal fisheries, successful regulation was found to have evolved within 15 years in two cases (Alanya, Tasucu), and 9 years in one case (Berkes, 1986a). Alarmed by the increasing numbers of users and escalating conflicts, fishermen in Alanya developed a system to regulate use: fishing sites were spaced sufficiently apart to avoid interference, and fisherman agreed among themselves to fish in rotation to ensure equitable access to best sites, with their starting position determined by drawing lots. Although only half of the licensed fishermen belonged to the local

marketing cooperative, the authority under which the system was operated, all participated in the process for creating and maintaining it (Berkes, 1986b).

Self-regulation of resource use to improve livelihood was also achieved by a local marketing cooperative of New Jersey fishermen. Because large catches depressed prices on the New York fresh fish market, a cooperative was formed to enhance producers' bargaining power. This cooperative decided on total catch levels for the fleet, and provided for the sharing of revenues regardless of the catch levels of individual boats. The pooling of revenues reduced the incentives to over-fish. Although the system was devised to raise prices, a spillover benefit may have been conservation (McCay, 1980).

A case from South India provides another example. In a village in Andhra Pradesh, villagers at the tail end of a large government-run irrigation scheme found that they were particularly vulnerable to fluctuations in water supply after the end of the rainy season. Although the traditional practice, in which households attempted to have plots at various locations throughout the village, reduced the variability in household agricultural production, villagers realized that careful management of village water resources could further increase and stabilize yields. A village water-user's association was formed and rules were developed. Irrigators were hired to manage the allocation of water; salaries were paid through taxes levied on landowners, based on the area irrigated. Along any particular irrigation ditch, fields closest to the source of the water could only be watered after downstream fields had been adequately wetted. The fact that prominent village landowners owned plots throughout the village helped to ensure their assistance in organizing a village-wide system of irrigation (Wade, 1986, 1987).

These case studies illustrate that people are not helpless but are able to organize, to monitor resource use by members, to allocate use rights among members, and to adjust aggregate utilization levels to maintain sustainable use of the resource (McEvoy, 1988). These cases, and those detailed elsewhere, indicate that under the appropriate circumstances, voluntary collective action is feasible and effective (McCay, 1978; National Research Council, 1986; McCay and Acheson, 1987; Ostrom, forthcoming; Wade, 1986, 1987).

*State Property.* Government ownership (state governance) permits the formulation of appropriate regulations for resource use. It also provides for the expression of public interest and for accountability. But state governance does not necessarily ensure sustainable use. Given that the officials who make decisions do not have the same time horizon or interests as private owners, the general public, or the government itself, this is not surprising.

One of the oft-mentioned problems of state ownership is the proliferation of such regulations. Smith points out, for example, that in a New England regional fishery, the combination of quotas, allocations, and trip limitations generated more than 100 different limits, with the result that there was

widespread violation of the law (Smith, 1988). Noncompliance of users and *de facto* open access has led to an assertion by some that better protection can be achieved under private- rather than state-property regimes.

State ownership is seldom associated with successful management in less-developed countries. The professional resource-management infrastructure of the state is usually poorly developed and enforcement of regulations problematic. In India, for example, communally-held forests were nationalized before the state had developed the capacity for management. Local communities are, however, starting to re-assert their cultural traditions of conservation (Gadgil, 1985, 1987; Gadgil and Iyer, 1989). In much of South Asia, Africa, and elsewhere, poorly-defended state property, in conjunction with population pressure, has led to widespread poaching of government forest and other resources. Repetto argues that "villagers who ruthlessly cut trees for firewood and fodder in government forests will zealously nurture and protect groves that belong to them or — if their community is sufficiently strong — to their village" (Repetto, 1986, pp. 30-31).

The logic of the argument of "The Tragedy of the Commons" is that private owners or state managers can and often do manage resources successfully. That is, these two property-rights regimes would provide the incentives to regulate use in a fashion consistent with sustainability. Implicitly Hardin argues that these incentives would be absent or weak for other regimes. However, the evidence indicates that complex interactions among the characteristics of the resource, the property-rights regime and other institutional arrangements, and the socio-economic environment contribute to the degree of management success. Success in the regulation of uses and users is not universally associated with any particular type of property-rights regime. Communal property, private property, and government property have all been associated both with success and failure.

## CONCLUSIONS

Hardin's model is insightful but incomplete. His conclusion of unavoidable tragedy follows from his assumptions of open access, lack of constraints on individual behavior, conditions in which demand exceeds supply, and resource users who are incapable of altering the rules. Actual common-property situations often do not conform to all four of these assumptions. This leads us to amend Hardin's heuristic fable. The "tragedy" may start as in Hardin (1968). But after several years of declining yields, the herdsmen are likely to get together to seek ways to (1) control access to the pasture, and (2) agree upon a set of rules of conduct, perhaps including stinting, that effectively limits exploitation. Whether or not the intended self-regulation

works depends on a number of factors. Here the simple model breaks down — no single metaphor can tell the full story. The medieval English commons usually were regulated by the community, sometimes effectively, sometimes not. The outcome was never so clear and deterministically predictable as in Hardin's model.

Thus, a major conclusion of the paper is the rejection of the simple one-to-one relationship between property-rights regime and outcome postulated by Hardin. The Hardin argument overlooks the important role of institutional arrangements that provide for exclusion and regulation of use. It also overlooks cultural factors (Feeny, 1988b; Charles, 1988). In order to understand the outcome, one needs to know the nature of the resource, the whole array of decision-making arrangements, including the property-rights regime, and the nature of the interactions among users and regulators (Oaker-son, 1986; Godwin and Shepard, 1979, p. 266; McEvoy, 1988, p. 229). Complex interactions are an important characteristic of commons situations, and models of the commons must take these interactions into account (for a review of the mathematics of describing complex interactive systems, see West and Shlesinger, 1990). Success may be found under three, not just two property-rights regimes.

The original Hardin paper did, however, allude to the potential viability of communal property. Hardin's (1968, p. 1247) phrase, "mutual coercion, mutually agreed upon" is consistent with communal-property arrangements, although he appears to have meant state institutions under representative government. Societies have the capacity to construct and enforce rules and norms that constrain the behavior of individuals. In many societies and in many situations, the capacity for concerted social action overcomes the divergence between individual and collective rationality. The cases discussed in this paper provide ample evidence of the ability of groups of users and local communities to organize and to manage local resources effectively. Contrary to assumptions by many common-property analysts, these communal-property arrangements have persisted. A diversity of societies in the past and present have independently devised, maintained, or adapted communal arrangements to manage common-property resources. Their persistence is not an historical accident; these arrangements build on knowledge of the resource and cultural norms that have evolved and been tested over time.

The new interest in communal property arrangements is perhaps related to the resurgence of interest in grass-roots democracy, public participation, and local-level planning. State property regimes in which officials exercise exclusive decision-making powers have been falling into disfavor. Given that there are many situations in which users have the capacity for self-management, it makes administrative and economic sense to involve them

in resource management. Communities of resource users are, however, no longer relatively isolated and resources often have multiple uses. Therefore, complete devolution may not be appropriate; it makes sense for the state to continue to play a role in resource conservation and allocation among communities of users. Shared governance or state regulation jointly with user self-management is thus a viable option. Such co-management can capitalize on the local knowledge and long-term self-interest of users, while providing for coordination with relevant uses and users over a wide geographic scope at potentially lower transaction (rule-enforcement) cost (McCay, 1988; Acheson, 1989a; Pinkerton, 1989).

Further, the logic of communal property can also be applied to resources that are global (rather than local) in scope. Here, tragedies are more difficult to prevent. This is perhaps why the World Conservation Strategy (1980) and the World Commission on Environment and Development (1987) both emphasized the global commons. Problems such as ozone depletion and carbon dioxide accumulation in the atmosphere are clearly global tragedies of the commons in the making. The solution of such problems will necessarily involve co-management on a large scale. The 1987 Montreal Protocol to protect the ozone layer is an example of international co-management. The case of oil pollution on the high seas, with various international conventions going back to 1954 (Cuyvers, 1984), and leading to reductions in accidental oil spills in the 1980's, the Alaska spill notwithstanding, demonstrates that international cooperation can be effective (World Resources Institute, 1988, p. 330).

The problem posed by Hardin over 20 years ago captured the attention of a multi-disciplinary collection of scholars and practitioners, including anthropologists, development planners, ecologists, economists, geographers, political scientists, resource scientists, and sociologists. *The Common Property Resource Digest*, published since December 1986, is distributed to more than 3500 individuals and institutions. Hardin's model provided insights and focused attention on important analytical issues. However, as with many seminal but simple models, Hardin's analysis has been shown by subsequent studies to be overly simplified and deterministic. As is the usual process in science, theory will have to be revised to take into account the new evidence (Feeny, 1989).

A new and more comprehensive theory for common-property resources must be able to account for sustainable resource management under communal-property regimes. The theory should be capable of accommodating user self-organization or the lack of it. Such a model can better explain whether and under what conditions sustainable resource management will occur, rather than simply predicting the demise of all resources held in common.

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