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GOVERNING THE COMMONS

The evolution of institutions for collective action

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can better search out variables from what we are reading and gathering. The help of Elizabeth Case, associate editor for this series, Sophia Prybylski at Cambridge University Press, and Emily Loose, editor at Cambridge University Press, is gratefully acknowledged. Patty Dalecki has, as always, provided professional editorial and production support that has greatly improved the quality of the manuscript. Her cheerful spirit has relieved pressures on many occasions.

1

Reflections on the commons

Hardly a week goes by without a major news story about the threatened destruction of a valuable natural resource. In June of 1989, for example, a *New York Times* article focused on the problem of overfishing in the Georges Bank about 150 miles off the New England coast. Catches of cod, flounder, and haddock are now only a quarter of what they were during the 1960s. Everyone knows that the basic problem is overfishing; however, those concerned cannot agree how to solve the problem. Congressional representatives recommend new national legislation, even though the legislation already on the books has been enforced only erratically. Representatives of the fishers argue that the fishing grounds would not be in such bad shape if the federal government had refrained from its sporadic attempts to regulate the fishery in the past. The issue in this case – and many others – is how best to limit the use of natural resources so as to ensure their long-term economic viability. Advocates of central regulation, of privatization, and of regulation by those involved have pressed their policy prescriptions in a variety of different arenas.

Similar situations occur on diverse scales ranging from small neighborhoods to the entire planet. The issues of how best to govern natural resources used by many individuals in common are no more settled in academia than in the world of politics. Some scholarly articles about the "tragedy of the commons" recommend that "the state" control most natural resources to prevent their destruction; others recommend that privatizing those resources will resolve the problem. What one can observe in the world, however, is that neither the state nor the market is uniformly successful in enabling individuals to sustain long-term, productive use of natural resource systems. Further, communities of individuals have relied on institutions resembling neither the state nor the market to govern some resource systems with reasonable degrees of success over long periods of time.

We do not yet have the necessary intellectual tools or models to understand the array of problems that are associated with governing and managing natural resource systems and the reasons why some institutions seem to work in some settings and not others. This book is an effort to (1) critique the foundations of policy analysis as applied to many natural resources, (2) present empirical examples of successful and unsuccessful efforts to govern and manage such resources, and (3) begin the effort to develop better intellectual tools to understand the capabilities and limitations of self-governing institutions for regulating many types of resources. To do this, I first describe the three models most frequently used to provide a foundation for recommending state or market solutions. I then pose theoretical and empirical alternatives to these models to begin to illustrate the diversity of solutions that go beyond states and markets. Using an institutional mode of analysis, I then attempt to explain how communities of individuals fashion different ways of governing the commons.

THREE INFLUENTIAL MODELS

The tragedy of the commons

Since Garrett Hardin's challenging article in *Science* (1968), the expression "the tragedy of the commons" has come to symbolize the degradation of the environment to be expected whenever many individuals use a scarce resource in common. To illustrate the logical structure of his model, Hardin asks the reader to envision a pasture "open to all." He then examines the structure of this situation from the perspective of a rational herder. Each herder receives a direct benefit from his own animals and suffers delayed costs from the deterioration of the commons when his and others' cattle overgraze. Each herder is motivated to add more and more animals because he receives the direct benefit of his own animals and bears only a share of the costs resulting from overgrazing. Hardin concludes:

> Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit – in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. (Hardin 1968, p. 1,244)

Hardin was not the first to notice the tragedy of the commons. Aristotle long ago observed that "what is common to the greatest number has the least care bestowed upon it. Everyone thinks chiefly of his own, hardly at all of the common interest" (*Politics*, Book II, ch. 3). Hobbes's parable of man in a state of nature is a prototype of the tragedy of the commons: Men

seek their own good and end up fighting one another. In 1833, William Forster Lloyd (1977) sketched a theory of the commons that predicted improvident use for property owned in common. More than a decade before Hardin's article, H. Scott Gordon (1954) clearly expounded similar logic in another classic: "The Economic Theory of a Common-Property Research: The Fishery." Gordon described the same dynamic as Hardin:

> There appears then, to be some truth in the conservative dictum that everybody's property is nobody's property. Wealth that is free for all is valued by no one because he who is foolhardy enough to wait for its proper time of use will only find that it has been taken by another. . . . The fish in the sea are valueless to the fisherman, because there is no assurance that they will be there for him tomorrow if they are left behind today. (Gordon 1954, p. 124)

John H. Dales (1968, p. 62) noted at the same time the perplexing problems related to resources "owned in common because there is no alternative!" Standard analyses in modern resource economics conclude that where a number of users have access to a common-pool resource, the total of resource units withdrawn from the resource will be greater than the optimal economic level of withdrawal (Clark 1976, 1980; Dasgupta and Heal 1979).

If the only "commons" of importance were a few grazing areas or fisheries, the tragedy of the commons would be of little general interest. That is not the case. Hardin himself used the grazing commons as a metaphor for the general problem of overpopulation. The "tragedy of the commons" has been used to describe such diverse problems as the Sahelian famine of the 1970s (Picardi and Seifert 1977), firewood crises throughout the Third World (Norman 1984; Thomson 1977), the problem of acid rain (R. Wilson 1985), the organization of the Mormon Church (Bullock and Baden 1977), the inability of the U.S. Congress to limit its capacity to overspend (Shepsle and Weingast 1984), urban crime (Neher 1978), public-sector/private-sector relationships in modern economies (Scharpf 1985, 1987, 1988), the problems of international cooperation (Snidal 1985), and communal conflict in Cyprus (Lumsden 1973). Much of the world is dependent on resources that are subject to the possibility of a tragedy of the commons.

The prisoner's dilemma game

Hardin's model has often been formalized as a prisoner's dilemma (PD) game (Dawes 1973, 1975).[1] Suppose we think of the players in a game as being herders using a common grazing meadow. For this meadow, there is an upper limit to the number of animals that can graze on the meadow for

a season and be well fed at the end of the season. We call that number L. For a two-person game, the "cooperate" strategy can be thought of as grazing $L/2$ animals for each herder. The "defect" strategy is for each herder to graze as many animals as he thinks he can sell at a profit (given his private costs), assuming that this number is greater than $L/2$. If both herders limit their grazing to $L/2$, they will obtain 10 units of profit, whereas if they both choose the defect strategy they will obtain zero profit. If one of them limits his number of animals to $L/2$, while the other grazes as many as he wants, the "defector" obtains 11 units of profit, and the "sucker" obtains -1. If each chooses independently without the capacity to engage in a binding contract, each chooses his dominant strategy, which is to defect. When they both defect, they obtain zero profit. Call this the Hardin herder game, or Game 1. It has the structure of a prisoner's dilemma game.[2]

The prisoner's dilemma game is conceptualized as a noncooperative game in which all players possess complete information. In noncooperative games, communication among the players is forbidden or impossible or simply irrelevant as long as it is not explicitly modeled as part of the game. If communication is possible, verbal agreements among players are presumed to be nonbinding unless the possibility of binding agreements is explicitly incorporated in the game structure (Harsanyi and Selten 1988, p. 3). "Complete information" implies that all players know the full structure of the game tree and the payoffs attached to outcomes. Players either know or do not know the current moves of other players depending on whether or not they are observable.

In a prisoner's dilemma game, each player has a dominant strategy in the sense that the player is always better off choosing this strategy – to defect

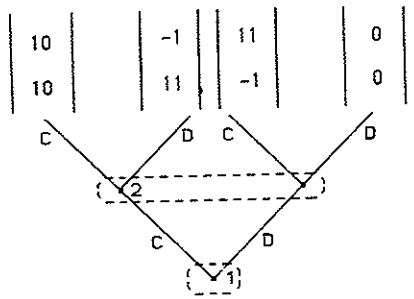

Figure 1.1. Game 1: The Hardin herder game.

– no matter what the other player chooses. When both players choose their dominant strategy, given these assumptions, they produce an equilibrium that is the third-best result for both. Neither has an incentive to change that is independent of the strategy choice of the other. The equilibrium resulting from each player selecting his or her "best" individual strategy is, however, not a Pareto-optimal outcome. A Pareto-optimal outcome occurs when there is no other outcome strictly preferred by at least one player that is at least as good for the others. In the two-person prisoner's dilemma game, both players prefer the (cooperate, cooperate) outcome to the (defect, defect) outcome. Thus, the equilibrium outcome is Pareto-inferior.

The prisoner's dilemma game fascinates scholars. The paradox that individually rational strategies lead to collectively irrational outcomes seems to challenge a fundamental faith that rational human beings can achieve rational results. In the introduction to a recently published book, *Paradoxes of Rationality and Cooperation*, Richmond Campbell explains the "deep attraction" of the dilemma:

> Quite simply, these paradoxes cast in doubt our understanding of rationality and, in the case of the Prisoner's Dilemma suggest that it is impossible for rational creatures to cooperate. Thus, they bear directly on fundamental issues in ethics and political philosophy and threaten the foundations of the social sciences. It is the scope of these consequences that explains why these paradoxes have drawn so much attention and why they command a central place in philosophical discussion. (Campbell 1985, p. 3)

The deep attraction of the dilemma is further illustrated by the number of articles written about it. At one count, 15 years ago, more than 2,000 papers had been devoted to the prisoner's dilemma game (Grofman and Pool 1975).

The logic of collective action

A closely related view of the difficulty of getting individuals to pursue their joint welfare, as contrasted to individual welfare, was developed by Mancur Olson (1965) in *The Logic of Collective Action*. Olson specifically set out to challenge the grand optimism expressed in group theory: that individuals with common interests would voluntarily act so as to try to further those interests (Bentley 1949; Truman 1958). On the first page of his book, Olson summarized that accepted view:

> The idea that groups tend to act in support of their group interests is supposed to follow logically from this widely accepted premise of rational, self-interested behavior. In other words, if the members of some group have a common interest or object, and if they would all be better off if that objective were achieved, it has been

thought to follow logically that the individuals in that group would, if they were rational and self-interested, act to achieve that objective. (Olson 1965, p.1)

Olson challenged the presumption that the possibility of a benefit for a group would be sufficient to generate collective action to achieve that benefit. In the most frequently quoted passage of his book, Olson argued that

unless the number of individuals is quite small, or unless there is coercion or some other special device to make individuals act in their common interest, *rational, self-interested individuals will not act to achieve their common or group interests.* (Olson 1965, p. 2; emphasis in original)

Olson's argument rests largely on the premise that one who cannot be excluded from obtaining the benefits of a collective good once the good is produced has little incentive to contribute voluntarily to the provision of that good. His book is less pessimistic than it is asserted to be by many who cite this famous passage. Olson considers it an open question whether intermediate-size groups will or will not voluntarily provide collective benefits. His definition of an intermediate-size group depends not on the number of actors involved but on how noticeable each person's actions are.

The tragedy of the commons, the prisoner's dilemma, and the logic of collective action are closely related concepts in the models that have defined the accepted way of viewing many problems that individuals face when attempting to achieve collective benefits. At the heart of each of these models is the free-rider problem. Whenever one person cannot be excluded from the benefits that others provide, each person is motivated not to contribute to the joint effort, but to free-ride on the efforts of others. If all participants choose to free-ride, the collective benefit will not be produced. The temptation to free-ride, however, may dominate the decision process, and thus all will end up where no one wanted to be. Alternatively, some may provide while others free-ride, leading to less than the optimal level of provision of the collective benefit. These models are thus extremely useful for explaining how perfectly rational individuals can produce, under some circumstances, outcomes that are not "rational" when viewed from the perspective of all those involved.

What makes these models so interesting and so powerful is that they capture important aspects of many different problems that occur in diverse settings in all parts of the world. What makes these models so dangerous – when they are used metaphorically as the foundation for policy – is that the constraints that are assumed to be fixed for the purpose of analysis are taken on faith as being fixed in empirical settings, unless external author-

ities change them.[3] The prisoners in the famous dilemma cannot change the constraints imposed on them by the district attorney; they are in jail. Not all users of natural resources are similarly incapable of changing their constraints. As long as individuals are viewed as prisoners, policy prescriptions will address this metaphor. I would rather address the question of how to enhance the capabilities of those involved to change the constraining rules of the game to lead to outcomes other than remorseless tragedies.

THE METAPHORICAL USE OF MODELS

These three models and their many variants are diverse representations of a broader and still-evolving theory of collective action. Much more work will be needed to develop the theory of collective action into a reliable and useful foundation for policy analysis. Considerable progress has been made during the past three decades by theorists and empirically oriented social scientists. The sweeping conclusions of the first variants of this theory have given way to a more qualified body of knowledge involving many more variables and explicit base conditions.

As an evolving, rather than completed, theory, it provokes disagreement regarding the importance or insignificance of some variables and how best to specify key relationships.[4] The results from more recent work, particularly work focusing on the dynamic aspects of relevant empirical settings, have begun to generate more optimistic predictions than did earlier models; see, in particular, the work of Axelrod (1981, 1984) and Kreps and Wilson (1982). This is one of the most exciting areas in the social sciences, for although considerable cumulation has already occurred, some deep questions remain unanswered. Some of these puzzles are key to understanding how individuals jointly using a common-pool resource might be able to achieve an effective form of governing and managing their own commons. These puzzles are examined in Chapter 2.

Much that has been written about common-pool resources, however, has uncritically accepted the earlier models and the presumption of a remorseless tragedy (Nebel 1987). Scholars have gone so far as to recommend that "Hardin's 'Tragedy of the Commons' should be required reading for all students . . . and, if I had my way, for all human beings."[5] Policy prescriptions have relied to a large extent on one of the three original models, but those attempting to use these models as the basis for policy prescription frequently have achieved little more than a metaphorical use of the models.

When models are used as metaphors, an author usually points to the similarity between one or two variables in a natural setting and one or two

variables in a model. If calling attention to similarities is all that is intended by the metaphor, it serves the usual purpose of rapidly conveying information in graphic form. These three models have frequently been used metaphorically, however, for another purpose. The similarity between the many individuals jointly using a resource in a natural setting and the many individuals jointly producing a suboptimal result in the model has been used to convey a sense that further similarities are present. By referring to natural settings as "tragedies of the commons," "collective-action problems," "prisoner's dilemmas," "open-access resources," or even "common-property resources," the observer frequently wishes to invoke an image of helpless individuals caught in an inexorable process of destroying their own resources. An article in the December 10, 1988, issue of *The Economist* goes so far as to assert that fisheries can be managed successfully only if it is recognized that "left to their own devices, fisherman will overexploit stocks," and "to avoid disaster, managers must have effective hegemony over them."

Public officials sometimes do no more than evoke grim images by briefly alluding to the popularized versions of the models, presuming, as self-evident, that the same processes occur in all natural settings. The Canadian minister of fisheries and oceans, for example, captured the color of the models in a 1980 speech:

> If you let loose that kind of economic self-interest in fisheries, with everybody fishing as he wants, taking from a resource that belongs to no individual, you end up destroying your neighbour and yourself. In free fisheries, good times create bad times, attracting more and more boats to chase fewer and fewer fish, producing less and less money to divide among more and more people.
>
> (Romeo LeBlanc, speaking at the 50th anniversary meeting of the United Maritime Fishermen, March 19, 1980; quoted by Matthews and Phyne 1988)

The implication, of course, was that Canadian fisheries universally met that description – an empirically incorrect inference.[6] But many observers have come to assume that most resources are like those specified in the three models. As such, it has been assumed that the individuals have been caught in a grim trap. The resulting policy recommendations have had an equally grim character.

CURRENT POLICY PRESCRIPTIONS

Leviathan as the "only" way

Ophuls (1973, p. 228) argued, for example, that "because of the tragedy of the commons, environmental problems cannot be solved through cooperation . . . and the rationale for government with major coercive

powers is overwhelming." Ophuls concluded that "even if we avoid the tragedy of the commons, it will *only* be by recourse to the tragic necessity of Leviathan" (1973, p. 229; emphasis added).[7] Garrett Hardin argued a decade after his earlier article that we are enveloped in a "cloud of ignorance" about "the true nature of the fundamental political systems and the effect of each on the preservation of the environment" (1978, p. 310). The "cloud of ignorance" did not, however, prevent him from presuming that the only alternatives to the commons dilemma were what he called "a private enterprise system," on the one hand, or "socialism," on the other (1978, p. 314). With the assurance of one convinced that "the alternative of the commons is too horrifying to contemplate" (1968, p. 1,247), Hardin indicated that change would have to be instituted with "whatever force may be required to make the change stick" (1978, p. 314). In other words, "if ruin is to be avoided in a crowded world, people must be responsive to a coercive force outside their individual psyches, a 'Leviathan,' to use Hobbes's term" (Hardin 1978, p. 314).

The presumption that an external Leviathan is necessary to avoid tragedies of the commons leads to recommendations that central governments control most natural resource systems. Heilbroner (1974) opined that "iron governments," perhaps military governments, would be necessary to achieve control over ecological problems. In a less draconian view, Ehrenfeld (1972, p. 322) suggested that if "private interests cannot be expected to protect the public domain then external regulation by public agencies, governments, or international authorities is needed." In an analysis of the problems involved in water resource management in developing countries, Carruthers and Stoner (1981, p. 29) argued that without public control, "overgrazing and soil erosion of communal pastures, or less fish at higher average cost," would result. They concluded that "common property resources *require* public control if economic efficiency is to result from their development" (1981, p. 29; emphasis added).[8] The policy advice to centralize the control and regulation of natural resources, such as grazing lands, forests, and fisheries, has been followed extensively, particularly in Third World countries.

One way to illustrate these proponents' image of centralized control is to modify the Hardin herder game using the assumptions that underlie this policy advice. The proponents of centralized control want an external government agency to decide the specific herding strategy that the central authority considers best for the situation: The central authority will decide who can use the meadow, when they can use it, and how many animals can be grazed. Let us assume that the central authority decides to impose a penalty of 2 profit units on anyone who is considered by that authority to

be using a defect strategy. Assuming that the central agency knows the sustainable yield of the meadow (L) and can unfailingly discover and penalize any herder using the defect strategy, the newly restructured game imposed by the central authority is represented in Game 2. Now, the solution to Game 2 is (cooperate, cooperate). Both players receive 10 profit units each, rather than the zero units they would have received in Game 1. If an external authority accurately determines the capacity of a common-pool resource, unambiguously assigns this capacity, monitors actions, and unfailingly sanctions noncompliance, then a centralized agency can transform the Hardin herder game to generate an optimally efficient equilibrium for the herders. Little consideration is given to the cost of creating and maintaining such an agency. This is seen as exogenous to the problem and is not included as a parameter of Game 2.[9]

The optimal equilibrium achieved by following the advice to centralize control, however, is based on assumptions concerning the accuracy of information, monitoring capabilities, sanctioning reliability, and zero costs of administration. Without valid and reliable information, a central agency could make several errors, including setting the carrying capacity or the fine too high or too low, sanctioning herders who cooperate, or not sanctioning defectors. The implications of all forms of incomplete information are interesting. However, as an example, I shall focus entirely on the implications arising from a central agency's incomplete information about the herders' strategies. The implicit assumption of Game 2 is that the central agency monitors all actions of the herders costlessly and imposes sanctions correctly.

In Game 3, we assume that the central agency has complete information about the carrying capacity of the meadow, but incomplete information about the particular actions of the herders. The central agency conse-

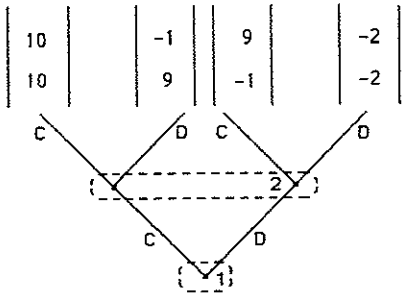

Figure 1.2. Game 2: The central-authority game with complete information.

quently makes errors in imposing punishments. Let us assume that the central agency punishes defections (the correct response) with probability y and fails to punish defections with probability $1 - y$ (the erroneous response). Let us also assume that the central agency punishes cooperative actions (the erroneous response) with probability x and does not punish cooperative actions (the correct response) with probability $1 - x$. The payoff parameters are illustrated in Figure 1.3.

A central agency with complete information would make no errors in its punishment level; in that case, $x = 0$ and $y = 1$. Game 2 would then be a special case of Game 3 in which $x = 0$ and $y = 1$. However, if the central agency does not have complete information about the actions of the herders, it imposes both types of sanctions correctly with a probability of 0.7 ($x = 0.3$, $y = 0.7$). An example of the specific payoffs for this game is shown as Game 4 in Figure 1.4. Given this payoff structure, the herders again face a prisoner's dilemma game. They will defect (overgraze) rather than cooperate (graze within the carrying capacity). In Game 4, as in the original Game 1, the equilibrium outcomes for the herders were (0, 0). In a game in which a central agency sanctions correctly with a probability of 0.7, the equilibrium outcomes are (−1.4, −1.4). The equilibrium of the regulated game has a lower value than that of the unregulated game. Given the carrying capacity and profit possibilities of Game 1, the central agency must have sufficient information so that it can correctly impose sanctions with a probability greater than 0.75 to avoid pushing the herders to the (D, D) equilibrium.[10]

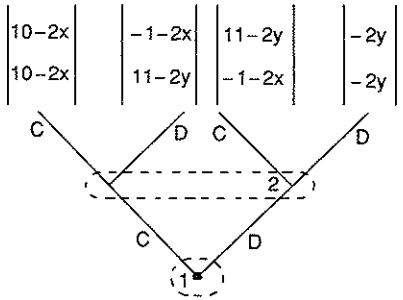

Figure 1.3. Game 3: The central-authority game with incomplete information.

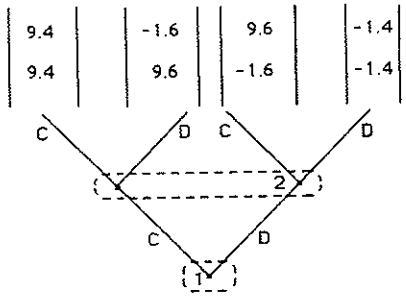

Figure 1.4. Game 4: An example of the central-authority game with incomplete information.

Privatization as the "only" way

Other policy analysts, influenced by the same models, have used equally strong terms in calling for the imposition of private property rights whenever resources are owned in common (Demsetz 1967; O. Johnson 1972). "Both the economic analysis of common property resources and Hardin's treatment of the tragedy of the commons" led Robert J. Smith (1981, p. 467) to suggest that "the *only* way to avoid the tragedy of the commons in natural resources and wildlife is to end the common-property system by creating a system of private property rights" (emphasis added); see also the work of Sinn (1984). Smith stressed that it is "by treating a resource as a common property that we become locked in its inexorable destruction" (1981, p. 465). Welch advocated the creation of full private rights to a commons when he asserted that "the establishment of full property rights is necessary to avoid the inefficiency of overgrazing" (1983, p. 171). He asserted that privatization of the commons was the optimal solution for all common-pool problems. His major concern was how to impose private ownership when those currently using a commons were unwilling to change to a set of private rights to the commons.

Those recommending the imposition of privatization on the herders would divide the meadow in half and assign half of the meadow to one herder and the other half to the second herder. Now each herder will be playing a *game against nature* in a smaller terrain, rather than a game against another player in a larger terrain. The herders now will need to invest in fences and their maintenance, as well as in monitoring and sanctioning activities to enforce their division of the grazing area (B. Field 1984, 1985b). It is presumed that each herder will now choose X/2 animals

to graze as a result of his own profit incentive.[11] This assumes that the meadow is perfectly homogeneous over time in its distribution of available fodder. If rainfall occurs erratically, one part of the grazing area may be lush with growth one year, whereas another part of the area may be unable to support X/2 animals. The rain may fall somewhere else the next year. In any given year, one of the herders may make no profit, and the other may enjoy a considerable return. If the location of lush growth changes dramatically from year to year, dividing the commons may impoverish both herders and lead to overgrazing in those parts where forage is temporarily inadequate. Of course, it will be possible for the herder who has extra fodder in one year to sell it to the other herder. Alternatively, it will be possible for the herders to set up an insurance scheme to share the risk of an uncertain environment. However, the setup costs for a new market or a new insurance scheme would be substantial and will not be needed so long as the herders share fodder and risk by jointly sharing a larger grazing area.

It is difficult to know exactly what analysts mean when they refer to the necessity of developing private rights to some common-pool resources (CPRs). It is clear that when they refer to land, they mean to divide the land into separate parcels and assign individual rights to hold, use, and transfer these parcels as individual owners desire (subject to the general regulations of a jurisdiction regarding the use and transfer of land). In regard to nonstationary resources, such as water and fisheries, it is unclear what the establishment of private rights means. As Colin Clark has pointed out, the "'tragedy of the commons' has proved particularly difficult to counteract in the case of marine fishery resources where the establishment of individual property rights is virtually out of the question" (1980, p. 117). In regard to a fugitive resource, a diversity of rights may be established giving individuals rights to use particular types of equipment, to use the resource system at a particular time and place, or to withdraw a particular quantity of resource units (if they can be found). But even when particular rights are unitized, quantified, and salable, the resource *system* is still likely to be owned in common rather than individually.[12] Again, referring to fisheries, Clark has argued that "common ownership is the fundamental fact affecting almost every regime of fishery management" (1980, p. 117).

The "only" way?

Analysts who find an empirical situation with a structure presumed to be a commons dilemma often call for the imposition of a solution by an external actor: The "only way" to solve a commons dilemma is by doing

X. Underlying such a claim is the belief that X is necessary and sufficient to solve the commons dilemma. But the content of X could hardly be more variable. One set of advocates presumes that a central authority must assume continuing responsibility to make unitary decisions for a particular resource. The other presumes that a central authority should parcel out ownership rights to the resource and then allow individuals to pursue their own self-interests within a set of well-defined property rights. Both centralization advocates and privatization advocates accept as a central tenet that institutional change must come from outside and be imposed on the individuals affected. Despite sharing a faith in the necessity and efficacy of "the state" to change institutions so as to increase efficiency, the institutional changes they recommend could hardly be further apart.

If one recommendation is correct, the other cannot be. Contradictory positions cannot both be right. I do not argue for either of these positions. Rather, I argue that both are too sweeping in their claims. Instead of there being a single solution to a single problem, I argue that many solutions exist to cope with many different problems. Instead of presuming that optimal institutional solutions can be designed easily and imposed at low cost by external authorities, I argue that "getting the institutions right" is a difficult, time-consuming, conflict-invoking process. It is a process that requires reliable information about time and place variables as well as a broad repertoire of culturally acceptable rules. New institutional arrangements do not work in the field as they do in abstract models unless the models are well specified and empirically valid and the participants in a field setting understand how to make the new rules work.

Instead of presuming that the individuals sharing a commons are inevitably caught in a trap from which they cannot escape, I argue that the capacity of individuals to extricate themselves from various types of dilemma situations *varies* from situation to situation. The cases to be discussed in this book illustrate both successful and unsuccessful efforts to escape tragic outcomes. Instead of basing policy on the presumption that the individuals involved are helpless, I wish to learn more from the experience of individuals in field settings. Why have some efforts to solve commons problems failed, while others have succeeded? What can we learn from experience that will help stimulate the development and use of a better theory of collective action – one that will identify the key variables that can enhance or detract from the capabilities of individuals to solve problems?

Institutions are rarely either private or public – "the market" or "the state." Many successful CPR institutions are rich mixtures of "private-like" and "public-like" institutions defying classification in a sterile dichotomy.

By "successful," I mean institutions that enable individuals to achieve productive outcomes in situations where temptations to free-ride and shirk are ever present. A competitive market – the epitome of private institutions – is itself a public good. Once a competitive market is provided, individuals can enter and exit freely whether or not they contribute to the cost of providing and maintaining the market. No market can exist for long without underlying public institutions to support it. In field settings, public and private institutions frequently are intermeshed and depend on one another, rather than existing in isolated worlds.

An alternative solution

To open up the discussion of institutional options for solving commons dilemmas, I want now to present a fifth game in which the herders themselves can make a binding contract to commit themselves to a cooperative strategy that they themselves will work out. To represent this arrangement within a noncooperative framework, additional moves must be overtly included in the game structure. A binding contract is interpreted within noncooperative game theory as one that is unfailingly enforced by an

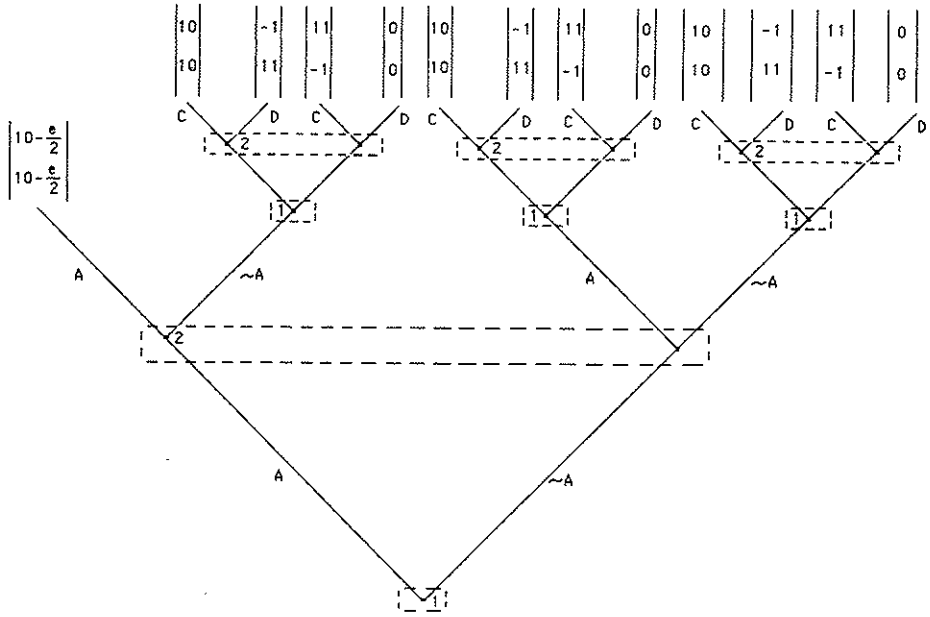

Figure 1.5. Game 5: Self-financed contract-enforcement game.

external actor – just as we interpreted the penalty posited earlier as being unfailingly enforced by the central authority.

A simple way to represent this is to add one parameter to the payoffs and a strategy to both herders' strategy sets.[13] The parameter is the cost of enforcing an agreement and will be denoted by *e*. The herders in Game 5 must now negotiate prior to placing animals on the meadow. During negotiations, they discuss various strategies for sharing the carrying capacity of the meadow and the costs of enforcing their agreement. Contracts are not enforceable, however, unless agreed to unanimously by the herders. Any proposal made by one herder that did not involve an equal sharing of the carrying capacity and of enforcement costs would be vetoed by the other herder in their negotiations. Consequently, the only feasible agreement – and the equilibrium of the resulting game – is for both herders to share equally the sustainable yield levels of the meadow and the costs of enforcing their agreement so long as each herder's share of the cost of enforcement is less than 10.[14]

Further, in Game 5, players can *always* guarantee that the worst they will do is the (defect, defect) outcome of Game 1. They are not dependent on the accuracy of the information obtained by a distant government official regarding their strategies. If one player suggests a contract based on incomplete or biased information, the other player can indicate an unwillingness to agree. They determine their own contract and ask the enforcer to enforce only that on which they have agreed. If the enforcer should decide to charge too much for its services [any number equal to or greater than $P_i(C, C) - P_i(D, D)$, $i = 1, 2$], neither player would agree to such a contract.

The "solution" of a commons-dilemma game through instrumentalities similar to Game 5 is not presented as the "only way" to solve a commons dilemma. It is merely one way. But this way has been almost totally ignored in both the policy-analysis literature and the formal-theory literature. Contemplating such an option raises numerous questions. First, might it be possible for the herders to hire a private agent to take on the role of enforcer? This is not as farfetched as it might seem at first. Many long-term business exchanges have the structure of a prisoner's dilemma.[15] Businesses are hesitant to accept promises of future performance rather than enforceable contracts, especially when beginning new business relationships. To reduce enforcement costs, however, a frequent practice is to use a private arbitrator rather than a civil court as the mechanism to achieve enforcement.[16] In *N*-person settings, all professional athletic leagues face problems similar to those illustrated here. During the play of a professional game, the temptation to cheat and break the rules is ever present. Further,

accidents do happen, and rules get broken, even by players who were intending to follow the rules. Athletic leagues typically employ private monitors to enforce their rules.[17]

As soon as we allow the possibility of a private party to take on the role of an external enforcer, the nature of the "solution" offered by Game 5 to the commons dilemma begins to generate a rich set of alternative applications. A self-financed contract-enforcement game allows the participants in the situation to exercise greater control over decisions about who will be allowed to graze and what limits will be placed on the number of animals, as compared with either Game 2 or Game 3. If the parties use a private arbitrator, they do not let the arbitrator impose an agreement on them. The arbitrator simply helps the parties find methods to resolve disputes that arise within the set of working rules to which the parties themselves have agreed. Arbitrators, courts, and other arrangements for enforcement and dispute resolution make it possible for individuals to initiate long-term arrangements that they could not otherwise undertake.[18] Further, as soon as one thinks about a "solution" like Game 5, it is a small step to thinking about the possibility of several arbitrators offering enforcement services at varying charges during the negotiation stage. The payoff-dominant equilibrium is to agree on that arbitrator who will enforce the contract at the lowest *e*.

The key difference between Game 5 and Games 2 and 3 is that the participants themselves design their own contracts in Game 5 in light of the information they have at hand. The herders, who use the same meadow year after year, have detailed and relatively accurate information about carrying capacity. They observe the behavior of other herders and have an incentive to report contractual infractions. Arbitrators may not need to hire monitors to observe the activities of the contracting parties. The self-interest of those who negotiated the contract will lead them to monitor each other and to report observed infractions so that the contract is enforced. A regulatory agency, on the other hand, always needs to hire its own monitors. The regulatory agency then faces the principal–agent problem of how to ensure that its monitors do their own job.

The proponents of the central-authority "solution" presume that such agencies have accurate information and are able to change incentives to produce something like Game 2. It is difficult for a central authority to have sufficient time-and-place information to estimate accurately both the carrying capacity of a CPR and the appropriate fines to induce cooperative behavior. I believe that situations like that in Game 3, in which incomplete information leads to sanctioning errors, occur more frequently than has been presumed in the policy literature. The need for external monitors and

enforcers is particularly acute when what is being enforced is a decision by an external agent who may impose excess costs on participants.

A further problem for consideration is that games in which enforcers have been arranged for by mutual agreement may be mistaken by analysts and public officials for games in which there have been *no* agreements about how to cooperate and enforce agreements. In other words, some examples of a "Game 5" may be mistaken for a "Game 1."[19] These situations may be construed to be "informal," carrying a presumption that they are not lawful. This goes to fundamental presumptions about the nature of governments as external authorities governing over societies.

As will be seen in the later discussion of empirical cases, users of CPRs have developed a wide diversity in their own agreements, which are enforced by many mechanisms. Some of the enforcement mechanisms are external governmental agencies. Some enforcement mechanisms involve members of the users' community who have been employed as monitors and enforcers. Some enforcement mechanisms involve the users themselves as their own monitors. When the enforcement mechanism is not an external governmental agency, some analysts presume that there is no enforcement. That is why Game 5 is mistaken for Game 1.

A self-financed contract-enforcement game is no panacea. Such institutional arrangements have many weaknesses in many settings. The herders can overestimate or underestimate the carrying capacity of the meadow. Their own monitoring system may break down. The external enforcer may not be able to enforce ex post, after promising to do so ex ante. A myriad of problems can occur in natural settings, as is also the case with the idealized central-regulation or private-property institutions.

The structure of the institutional arrangements that one finds in natural settings is, of course, far more complicated than the structure of any of the extremely simple games presented here for discussion. What I attempt to do with these simple games is to generate different ways of thinking about the mechanisms that individuals may use to extricate themselves from commons dilemmas – ways different from what one finds in much of the policy literature. To challenge this mind-set, one needs only simple mechanisms that illustrate alternatives to those that normally are presented as the dominant solutions.

An empirical alternative

Game 5 illustrated a theoretical alternative to centralization or privatization as ways to solve CPR problems. Let us now briefly consider a solution devised by participants in a field setting – Alanya, Turkey – that cannot be

characterized as either central regulation or privatization. The inshore fishery at Alanya, as described by Fikret Berkes (1986b), is a relatively small operation. Many of the approximately 100 local fishers operate in two- or three-person boats using various types of nets. Half of the fishers belong to a local producers' cooperative. According to Berkes, the early 1970s were the "dark ages" for Alanya. The economic viability of the fishery was threatened by two factors: First, unrestrained use of the fishery had led to hostility and, at times, violent conflict among the users. Second, competition among fishers for the better fishing spots had increased production costs, as well as the level of uncertainty regarding the harvest potential of any particular boat.

Early in the 1970s, members of the local cooperative began experimenting with an ingenious system for allotting fishing sites to local fishers. After more than a decade of trial-and-error efforts, the rules used by the Alanya inshore fishers are as follows:

- Each September, a list of eligible fishers is prepared, consisting of all licensed fishers in Alanya, regardless of co-op membership.
- Within the area normally used by Alanya fishers, all usable fishing locations are named and listed. These sites are spaced so that the nets set in one site will not block the fish that should be available at the adjacent sites.
- These named fishing locations and their assignments are in effect from September to May.
- In September, the eligible fishers draw lots and are assigned to the named fishing locations.
- From September to January, each day each fisher moves east to the next location. After January, the fishers move west. This gives the fishers equal opportunities at the stocks that migrate from east to west between September and January and reverse their migration through the area from January to May (Berkes 1986b, pp. 73–4).

The system has the effect of spacing the fishers far enough apart on the fishing grounds that the production capabilities at each site are optimized. All fishing boats also have equal chances to fish at the best spots. Resources are not wasted searching for or fighting over a site.[20] No signs of overcapitalization are apparent.

The list of fishing locations is endorsed by each fisher and deposited with the mayor and local gendarme once a year at the time of the lottery. The process of monitoring and enforcing the system is, however, accomplished by the fishers themselves as a by-product of the incentive created by the

rotation system. On a day when a given fisher is assigned one of the more productive spots, that fisher will exercise that option with certainty (leaving aside last-minute breakdowns in equipment). All other fishers can expect that the assigned fisher will be at the spot bright and early. Consequently, an effort to cheat on the system by traveling to a good spot on a day when one is assigned to a poor spot has little chance of remaining undetected. Cheating on the system will be observed by the very fishers who have rights to be in the best spots and will be willing to defend their rights using physical means if necessary. Their rights will be supported by everyone else in the system. The others will want to ensure that their own rights will not be usurped on the days when they are assigned good sites. The few infractions that have occurred have been handled easily by the fishers at the local coffeehouse (Berkes 1986b, p. 74).

Although this is not a private-property system, rights to use fishing sites and duties to respect these rights are well defined. And though it is not a centralized system, national legislation that has given such cooperatives jurisdiction over "local arrangements" has been used by cooperative officials to legitimize their role in helping to devise a workable set of rules. That local officials accept the signed agreement each year also enhances legitimacy. The actual monitoring and enforcing of the rules, however, are left to the fishers.

Central-government officials could not have crafted such a set of rules without assigning a full-time staff to work (actually fish) in the area for an extended period. Fishing sites of varying economic value are commonly associated with inshore fisheries (Christy 1982; Forman 1967), but they are almost impossible to map without extensive on-site experience. Mapping this set of fishing sites, such that one boat's fishing activities would not reduce the migration of fish to other locations, would have been a daunting challenge had it not been for the extensive time-and-place information provided by the fishers and their willingness to experiment for a decade with various maps and systems. Alanya provides an example of a self-governed common-property arrangement in which the rules have been devised and modified by the participants themselves and also are monitored and enforced by them.

The case of the Alanya inshore fishery is only one empirical example of the many institutional arrangements that have been devised, modified, monitored, and sustained by the users of renewable CPRs to constrain individual behavior that would, if unconstrained, reduce joint returns to the community of users. In addition to the case studies discussed in Chapters 3, 4, and 5, productive CPR institutional arrangements have been

well documented for many farmer-managed irrigation systems, communal forests, inshore fisheries, and grazing and hunting territories.[21]

Game 5 and empirical cases of successfully governed CPRs provide theoretical and empirical alternatives to the assertion that those involved cannot extricate themselves from the problems faced when multiple individuals use a given resource. The key to my argument is that some individuals have broken out of the trap inherent in the commons dilemma, whereas others continue remorsefully trapped into destroying their own resources.[22] This leads me to ask what differences exist between those who have broken the shackles of a commons dilemma and those who have not. The differences may have to do with factors *internal* to a given group. The participants may simply have no capacity to communicate with one another, no way to develop trust, and no sense that they must share a common future. Alternatively, powerful individuals who stand to gain from the current situation, while others lose, may block efforts by the less powerful to change the rules of the game. Such groups may need some form of external assistance to break out of the perverse logic of their situation.

The differences between those who have and those who have not extricated themselves from commons dilemmas may also have to do with factors *outside* the domain of those affected. Some participants do not have the autonomy to change their own institutional structures and are prevented from making constructive changes by external authorities who are indifferent to the perversities of the commons dilemma, or may even stand to gain from it. Also, there is the possibility that external changes may sweep rapidly over a group, giving them insufficient time to adjust their internal structures to avoid the suboptimal outcomes. Some groups suffer from perverse incentive systems that are themselves the results of policies pursued by central authorities. Many potential answers spring to mind regarding the question why some individuals do not achieve collective benefits for themselves, whereas others do. However, as long as analysts presume that individuals cannot change such situations themselves, they do not ask what internal or external variables can enhance or impede the efforts of communities of individuals to deal creatively and constructively with perverse problems such as the tragedy of the commons.

Policy prescriptions as metaphors

Policy analysts who would recommend a single prescription for commons problems have paid little attention to how diverse institutional arrange-

ments operate in practice. The centrists presume that unified authorities will operate in the field as they have been designed to do in the textbooks – determining the best policies to be adopted for a resource based on valid scientific theories and adequate information. Implementation of these policies without error is assumed. Monitoring and sanctioning activities are viewed as routine and nonproblematic.

Those advocating the private-property approach presume that the most efficient use patterns for CPRs will actually result from dividing the rights to access and control such resources. Systematic empirical studies have shown that private organization of firms dealing in goods such as electricity, transport, and medical services tends to be more efficient than governmental organization of such firms; for a review of this literature, see De Alessi (1980). Whether private or public forms are more efficient in industries in which certain potential beneficiaries cannot be excluded is, however, a different question. We are concerned with the types of institutions that will be most efficient for governing and managing diverse CPRs for which at least some potential beneficiaries cannot be excluded. Privatizing the ownership of CPRs need not have the same positive results as privatizing the ownership of an airline. Further, privatizing may not mean "dividing up" at all. Privatization can also mean assigning the exclusive right to harvest from a resource system to a single individual or firm.

Many policy prescriptions are themselves no more than metaphors. Both the centralizers and the privatizers frequently advocate oversimplified, idealized institutions – paradoxically, almost "institution-free" institutions. An assertion that central regulation is necessary tells us nothing about the way a central agency should be constituted, what authority it should have, how the limits on its authority should be maintained, how it will obtain information, or how its agents should be selected, motivated to do their work, and have their performances monitored and rewarded or sanctioned. An assertion that the imposition of private property rights is necessary tells us nothing about how that bundle of rights is to be defined, how the various attributes of the goods involved will be measured, who will pay for the costs of excluding nonowners from access, how conflicts over rights will be adjudicated, or how the residual interests of the right-holders in the resource system itself will be organized.

An important lesson that one learns by carefully studying the growing number of systematic studies by scholars associated with "the new institutionalism" is that these "institutional details" are important.[23] Whether or not any equilibria are possible and whether or not an equilibrium would be an improvement for the individuals involved (or for others who are in turn affected by these individuals) will depend on the particular structures

of the institutions. In the most general sense, all institutional arrangements can be thought of as games in extensive form. As such, the particular options available, the sequencing of those options, the information provided, and the relative rewards and punishments assigned to different sequences of moves can all change the pattern of outcomes achieved. Further, the particular structure of the physical environment involved also will have a major impact on the structure of the game and its results. Thus, a set of rules used in one physical environment may have vastly different consequences if used in a different physical environment.

Policies based on metaphors can be harmful

Relying on metaphors as the foundation for policy advice can lead to results substantially different from those presumed to be likely. Nationalizing the ownership of forests in Third World countries, for example, has been advocated on the grounds that local villagers cannot manage forests so as to sustain their productivity and their value in reducing soil erosion. In countries where small villages had owned and regulated their local communal forests for generations, nationalization meant expropriation. In such localities, villagers had earlier exercised considerable restraint over the rate and manner of harvesting forest products. In some of these countries, national agencies issued elaborate regulations concerning the use of forests, but were unable to employ sufficient numbers of foresters to enforce those regulations. The foresters who were employed were paid such low salaries that accepting bribes became a common means of supplementing their income. The consequence was that nationalization created *open-access resources* where limited-access *common-property resources* had previously existed. The disastrous effects of nationalizing formerly communal forests have been well documented for Thailand (Feeny 1988a), Niger (Thomson 1977; Thomson, Feeny, and Oakerson 1986), Nepal (Arnold and Campbell 1986; Messerschmidt 1986), and India (Gadgil and Iyer 1989). Similar problems occurred in regard to inshore fisheries when national agencies presumed that they had exclusive jurisdiction over all coastal waters (Cordell and McKean 1986; W. Cruz 1986; Dasgupta 1982; Panayoutou 1982; Pinkerton 1989a).

A CHALLENGE

An important challenge facing policy scientists is to develop theories of human organization based on realistic assessment of human capabilities and limitations in dealing with a variety of situations that initially share

some or all aspects of a tragedy of the commons. Empirically validated theories of human organization will be essential ingredients of a policy science that can inform decisions about the likely consequences of a multitude of ways of organizing human activities. Theoretical inquiry involves a search for regularities. It involves abstraction from the complexity of a field setting, followed by the positing of theoretical variables that underlie observed complexities. Specific models of a theory involve further abstraction and simplification for the purpose of still finer analysis of the logical relationships among variables in a closed system. As a theorist, and at times a modeler, I see these efforts at the core of a policy science.

One can, however, get trapped in one's own intellectual web. When years have been spent in the development of a theory with considerable power and elegance, analysts obviously will want to apply this tool to as many situations as possible. The power of a theory is exactly proportional to the diversity of situations it can explain. All theories, however, have limits. Models of a theory are limited still further because many parameters must be fixed in a model, rather than allowed to vary. Confusing a model – such as that of a perfectly competitive market – with the theory of which it is one representation can limit applicability still further.

Scientific knowledge is as much an understanding of the diversity of situations for which a theory or its models are relevant as an understanding of its limits. The conviction that all physical structures could be described in terms of a set of perfect forms – circles, squares, and triangles – limited the development of astronomy until Johannes Kepler broke the bonds of classical thought and discovered that the orbit of Mars was elliptical – a finding that Kepler himself initially considered to be no more than a pile of dung (Koestler 1959). Godwin and Shepard (1979) pointed out a decade ago that policy scientists were doing the equivalent of "Forcing Squares, Triangles and Ellipses into a Circular Paradigm" by using the commons-dilemma model without serious attention to whether or not the variables in the empirical world conformed to the theoretical model. Many theoretical and empirical findings have been reported since Godwin and Shepard's article that should have made policy scientists even more skeptical about relying on a limited set of models to analyze the diversity of situations broadly referred to as CPR problems. Unfortunately, many analysts – in academia, special-interest groups, governments, and the press – still presume that common-pool problems are all dilemmas in which the participants themselves cannot avoid producing suboptimal results, and in some cases disastrous results.

What is missing from the policy analyst's tool kit – and from the set of accepted, well-developed theories of human organization – is an ade-

quately specified theory of collective action whereby a group of principals can organize themselves voluntarily to retain the residuals of their own efforts. Examples of self-organized enterprises abound. Most law firms are obvious examples: A group of lawyers will pool their assets to purchase a library and pay for joint secretarial and research assistance. They will develop their own internal governance mechanisms and formulas for allocating costs and benefits to the partners. Most cooperatives are also examples. The cases of self-organized and self-governed CPRs that we consider in Chapter 3 are also examples. But until a theoretical explanation – based on human choice – for self-organized and self-governed enterprises is fully developed and accepted, major policy decisions will continue to be undertaken with a presumption that individuals cannot organize themselves and always need to be organized by external authorities.

Further, all organizational arrangements are subject to stress, weakness, and failure. Without an adequate theory of self-organized collective action, one cannot predict or explain when individuals will be unable to solve a common problem through self-organization alone, nor can one begin to ascertain which of many intervention strategies might be effective in helping to solve particular problems. As discussed earlier, there is a considerable difference between the presumption that a regulatory agency should be established and the presumption that a reliable court system is needed to monitor and enforce self-negotiated contracts. If the theories being used in a policy science do not include the possibility of self-organized collective action, then the importance of a court system that can be used by self-organizing groups to monitor and enforce contracts will not be recognized.[24]

I hope this inquiry will contribute to the development of an empirically supported theory of self-organizing and self-governing forms of collective action. What I attempt to do in this volume is to combine the strategy used by many scholars associated with the "new institutionalism" with the strategy used by biologists for conducting empirical work related to the development of a better theoretical understanding of the biological world.

As an institutionalist studying empirical phenomena, I presume that individuals try to solve problems as effectively as they can. That assumption imposes a discipline on me. Instead of presuming that some individuals are incompetent, evil, or irrational, and others are omniscient, I presume that individuals have very similar limited capabilities to reason and figure out the structure of complex environments. It is my responsibility as a scientist to ascertain what problems individuals are trying to solve and what factors help or hinder them in these efforts. When the problems that I observe involve lack of predictability, information, and trust, as well as high levels

of complexity and transactional difficulties, then my efforts to explain must take these problems overtly into account rather than assuming them away. In developing an explanation for observed behavior, I draw on a rich literature written by other scholars interested in institutions and their effects on individual incentives and behaviors in field settings.

Biologists also face the problem of studying complex processes that are poorly understood. Their scientific strategy frequently has involved identifying for empirical observation the simplest possible organism in which a process occurs in a clarified, or even exaggerated, form. The organism is not chosen because it is representative of all organisms. Rather, the organism is chosen because particular processes can be studied more effectively using this organism than using another.

My "organism" is a type of human situation. I call this situation a CPR situation and define exactly what I mean by this and other key terms in Chapter 2. In this volume, I do not include all potential CPR situations within the frame of reference. I focus entirely on small-scale CPRs, where the CPR is itself located within one country and the number of individuals affected varies from 50 to 15,000 persons who are heavily dependent on the CPR for economic returns. These CPRs are primarily inshore fisheries, smaller grazing areas, groundwater basins, irrigation systems, and communal forests. Because these are relatively small-scale situations, serious study is more likely to penetrate the surface complexity to identify underlying similarities and processes. Because the individuals involved gain a major part of their economic return from the CPRs, they are strongly motivated to try to solve common problems to enhance their own productivity over time. The effort to self-organize in these situations may be somewhat exaggerated, but that is exactly why I want to study this process in these settings. Further, when self-organization fails, I know that it is not because the collective benefits that could have been obtained were unimportant to the participants.

There are limits on the types of CPRs studied here: (1) renewable rather than nonrenewable resources, (2) situations where substantial scarcity exists, rather than abundance, and (3) situations in which the users can substantially harm one another, but not situations in which participants can produce major external harm for others. Thus, all asymmetrical pollution problems are excluded, as is any situation in which a group can form a cartel and control a sufficient part of the market to affect market price.

In the empirical studies, I present a synopsis of important CPR cases that have aided my understanding of the processes of self-organization and self-governance. These cases are in no sense a "random" sample of cases. Rather, these are cases that provide clear information about the processes

involved in (1) governing long-enduring CPRs, (2) transforming existing institutional arrangements, and (3) failing to overcome continued CPR problems. These cases can thus be viewed as a collection of the most salient raw materials with which I have worked in my effort to understand how individuals organize and govern themselves to obtain collective benefits in situations where the temptations to free-ride and to break commitments are substantial.

From an examination and analysis of these cases, I attempt to develop a series of reasoned conjectures about how it is possible that some individuals organize themselves to govern and manage CPRs and others do not. I try to identify the underlying design principles of the institutions used by those who have successfully managed their own CPRs over extended periods of time and why these may affect the incentives for participants to continue investing time and effort in the governance and management of their own CPRs. I compare the institutions used in successful and unsuccessful cases, and I try to identify the internal and external factors that can impede or enhance the capabilities of individuals to use and govern CPRs.

I hope these conjectures contribute to the development of an empirically valid theory of self-organization and self-governance for at least one well-defined universe of problematical situations. That universe contains a substantial proportion of renewable resources heavily utilized by human beings in different parts of the world. It is estimated, for example, that 90% of the world's fishermen and over half of the fish consumed each year are captured in the small-scale, inshore fisheries included within the frame of this study (Panayoutou 1982, p. 49). Further, my choice of the CPR environment for intensive study was based on a presumption that I could learn about the processes of self-organization and self-governance of relevance to a somewhat broader set of environments.

Given the similarity between many CPR problems and the problems of providing small-scale collective goods, the findings from this volume should contribute to an understanding of the factors that can enhance or detract from the capabilities of individuals to organize collective action related to providing local public goods. All efforts to organize collective action, whether by an external ruler, an entrepreneur, or a set of principals who wish to gain collective benefits, must address a common set of problems. These have to do with coping with free-riding, solving commitment problems, arranging for the supply of new institutions, and monitoring individual compliance with sets of rules. A study that focuses on how individuals avoid free-riding, achieve high levels of commitment, arrange for new institutions, and monitor conformity to a set of rules in CPR environments should contribute to an understanding of how in-

dividuals address these crucial problems in some other settings as well.

Let me now give a brief sketch of how this book is organized. In Chapter 2, I define what I mean by a CPR situation and individual choice in a CPR situation. Then I examine a series of crucial questions that any theory of collective action must answer. To conclude the chapter, I examine two assumptions that have framed prior work and discuss the alternatives that frame my analysis. The empirical part of this volume is contained in Chapters 3, 4, and 5, where I examine specific cases of long-enduring CPR institutions and resources, the origin and development of CPR institutions, and CPR failures and fragilities. At the end of each empirical chapter, I consider what can be learned from the cases in that chapter that will contribute toward the development of a better theory of self-organization related to CPR environments. In Chapter 6, I pull together the theoretical reflections contained at the ends of Chapters 3, 4, and 5 and address the implications of these conjectures for the design of self-organizing and self-governing institutions.

2

An institutional approach to the study of self-organization and self-governance in CPR situations

In Chapter 1, I described my strategy as that of a "new institutionalist" who has picked small-scale CPR situations to study because the processes of self-organization and self-governance are easier to observe in this type of situation than in many others. The central question in this study is how a group of principals who are in an interdependent situation can organize and govern themselves to obtain continuing joint benefits when all face temptations to free-ride, shirk, or otherwise act opportunistically. Parallel questions have to do with the combinations of variables that will (1) increase the initial likelihood of self-organization, (2) enhance the capabilities of individuals to continue self-organized efforts over time, or (3) exceed the capacity of self-organization to solve CPR problems without external assistance of some form.

This chapter has several objectives. First, I define what I mean by CPRs and how I view individual behaviors in complex and uncertain CPR situations. Then I examine the general problem facing individuals in CPR situations: how to organize to avoid the adverse outcomes of independent action. This general problem is solved by external agents in two well-accepted theories: the theory of the firm and the theory of the state. These explain how new institutions are supplied, how commitments are obtained, and how the actions of agents and subjects are monitored effectively, using in one case the firm, and in the other state, as an organizational device. How a group of principals – a community of citizens – can organize themselves to solve the problems of institutional supply, commitment, and monitoring is still a theoretical puzzle. Given that some individuals solve this puzzle, whereas others do not, a study of successful and unsuccessful efforts to solve CPR problems should address important issues related to the theory of collective action and the development of better policies related to CPRs. Many efforts to analyze collective-action problems have

framed the analysis by presuming that all such problems can be represented as prisoner's dilemma (PD) games, that a single level of analysis is sufficient, and that transactions costs are insignificant and can be ignored. In the last section of this chapter, I propose assumptions that are alternatives to those that normally frame the analysis of collective action.

THE CPR SITUATION

CPRs and resource units

The term "common-pool resource" refers to a natural or man-made resource system that is sufficiently large as to make it costly (but not impossible) to exclude potential beneficiaries from obtaining benefits from its use. To understand the processes of organizing and governing CPRs, it is essential to distinguish between the *resource system* and the flow of *resource units* produced by the system, while still recognizing the dependence of the one on the other.

Resource systems are best thought of as stock variables that are capable, under favorable conditions, of producing a maximum quantity of a flow variable without harming the stock or the resource system itself. Examples of resource systems include fishing grounds, groundwater basins, grazing areas, irrigation canals, bridges, parking garages, mainframe computers, and streams, lakes, oceans, and other bodies of water. Resource units are what individuals appropriate or use from resource systems. Resource units are typified by the tons of fish harvested from a fishing ground, the acre-feet or cubic meters of water withdrawn from a groundwater basin or an irrigation canal, the tons of fodder consumed by animals from a grazing area, the number of bridge crossings used per year by a bridge, the parking spaces filled, the central processing units consumed by those sharing a computer system, and the quantity of biological waste absorbed per year by a stream or other waterway. The distinction between the resource as *a stock* and the harvest of use units as a *flow* is especially useful in connection with *renewable* resources, where it is possible to define a replenishment rate. As long as the average rate of withdrawal does not exceed the average rate of replenishment, a renewable resource is sustained over time.[1]

Access to a CPR can be limited to a single individual or firm or to multiple individuals or teams of individuals who use the resource system at the same time. The CPRs studied in this volume are used by multiple individuals or firms. Following Plott and Meyer (1975), I call the process of withdrawing resource units from a resource system "appropriation." Those who withdraw such units are called "appropriators."[2] One term –

"appropriator" – can thus be used to refer to herders, fishers, irrigators, commuters, and anyone else who appropriates resource units from some type of resource system. In many instances appropriators use or consume the resource units they withdraw (e.g., where fishers harvest primarily for consumption). Appropriators also use resource units as inputs into production processes (e.g., irrigators apply water to their fields to produce rice). In other instances, the appropriators immediately transfer ownership of resource units to others, who are then the users of the resource units (e.g., fishers who sell their catch as soon as possible after arrival at a port).

The analysis of scarce, renewable resources is made from the perspective of the appropriators. This is not the only perspective that can be used in an analysis of complex CPR problems. If the appropriators of a resource unit gain considerable market power, such as by creating a cartel to influence price, their strategies affect themselves as well as others. This analysis relates to situations in which CPR appropriators have no power in a final-goods market, nor do their actions have significant impact on the environment of others living outside the range of their CPR.

The term I use to refer to those who arrange for the provision of a CPR is "providers." I use the term "producer" to refer to anyone who actually constructs, repairs, or takes actions that ensure the long-term sustenance of the resource system itself. Frequently, providers and producers are the same individuals, but they do not have to be (V. Ostrom, Tiebout, and Warren 1961). A national government may provide an irrigation system in the sense of arranging for its financing and design. It may then arrange with local farmers to produce and maintain it. If local farmers are given the authority to arrange for maintenance, then they become both the providers and the producers of maintenance activities related to a CPR.

A resource system can be jointly provided and/or produced by more than one person or firm. The actual process of appropriating resource units from the CPR can be undertaken by multiple appropriators simultaneously or sequentially. The resource units, however, *are not subject to joint use or appropriation*. The fish harvested by one boat are not there for someone else. The water spread on one farmer's fields cannot be spread onto someone else's fields. Thus, the resource units are not jointly used, but the resource system is subject to joint use. Once multiple appropriators rely on a given resource system, improvements to the system are simultaneously available to all appropriators. It is costly (and in some cases infeasible) to exclude one appropriator of a resource system from improvements made to the resource system itself. All appropriators benefit from maintenance performed on an irrigation canal, a bridge, or a computer system whether they contribute or not.

Failure to distinguish between the subtractability of the resource units and the jointness of the resource system has in the past contributed to confusion about the relationship of CPRs to public or collective goods.[3] Michael Taylor recognized the difference between CPRs and collective goods when he wrote the following:

> There is, in particular, a very important class of collective action problems which arise in connection with the use of resources to which there is open access – resources, that is, which nobody is prevented from using. These resources need not be public goods. (M. Taylor 1987, p. 3)

The relatively high costs of physically excluding joint appropriators from the resource or from improvements made to the resource system are similar to the high costs of excluding potential beneficiaries from public goods. This shared attribute is responsible for the ever present temptation to free-ride that exists in regard to both CPRs and public goods. There is as much temptation to avoid contributing to the provision of a resource system as there is to avoid contributing to the provision of public security or weather forecasts. Theoretical propositions that are derived solely from the difficulty of exclusion are applicable to the *provision* of both CPRs and collective goods.

But one's use of a weather forecast does not subtract from the availability of that forecast to others, just as one's consumption of public security does not reduce the general level of security available in a community.[4] "Crowding effects" and "overuse" problems are chronic in CPR situations, but absent in regard to pure public goods. The subractability of the resource unit leads to the possibility of approaching the limit of the number of resource units produced by a CPR. When the CPR is a man-made structure, such as a bridge, approaching the limit of crossing units will lead to congestion. When the CPR is a biological resource, such as a fishery or a forest, approaching the limit of resource units not only may produce short-run crowding effects but also may destroy the capability of the resource itself to continue producing resource units. Even a physical resource, such as a bridge, can be destroyed by heavier use than was allowed for in its engineering specifications.

Thus, propositions derived from a theory of public goods that are based on the nonsubtractive attributes of those goods are *not* applicable to an analysis of *appropriation* and *use* of subtractable resource units. Appropriation and use of the resource units are more closely related to the theory of private goods than to the theory of public goods. On the other hand, the process of designing, implementing, and enforcing a set of rules to coordinate provision activities is equivalent to the provision of a local collective good. CPR appropriators who organize themselves to govern and manage a CPR are faced with some problems that are similar to those of appropriating private goods and other problems that are similar to those of providing public goods. Both aspects are intimately bound together physically and analytically. In a particular CPR, if problems associated with the appropriation of subtractable resource units become severe, local appropriators may refuse to undertake provision activities.[5] No appropriation of resource units can occur without a resource system. Without a fair, orderly, and efficient method of allocating resource units, local appropriators have little motivation to contribute to the continued provision of the resource system.

Rational appropriators in complex and uncertain situations

The decisions and actions of CPR appropriators to appropriate from and provide a CPR are those of broadly rational individuals who find themselves in complex and uncertain situations. An individual's choice of behavior in any particular situation will depend on how the individual learns about, views, and weighs the benefits and costs of actions and their perceived linkage to outcomes that also involve a mixture of benefits and costs.[6]

Organizing appropriators for collective action regarding a CPR is usually an uncertain and complex undertaking. Uncertainty has many external sources: the quantity and timing of rainfall, the temperature and amount of sunlight, the presence or absence of disease-bearing vectors, and the market prices of various inputs or final products. Other sources of uncertainty are internal to the CPR and the appropriators using the CPR. A major source of uncertainty is lack of knowledge. The exact structure of the resource system itself – its boundary and internal characteristics – must be established. Ascertaining the structure of the resource system may come about as a by-product of extended use and careful observation, as in the case of appropriating from a fishing ground or grazing range. Moreover, this folk knowledge must be preserved and passed along from one generation to the next. For a groundwater basin, on the other hand, the discovery of the internal structure may require a major investment in research by geologists and engineers.

How appropriators' actions affect the resource system, the yield of resource units, and each other's outcomes must also be ascertained.[7] It is not immediately apparent, for example, how one irrigator's forbearance in taking water from a canal will affect the yield obtained by that farmer or by other farmers. In some cases, a farmer located near the head of a system

may be able to curtail his water use substantially without a major impact on his own yield, while substantially enhancing the yields of downstream farmers. In other cases, the excess water taken by the farmer located near the headworks may subsequently also flow to farmers located lower in the system. Restraint by the farmer located higher in the system may not increase total yield. Uncertainties stemming from lack of knowledge may be reduced over time as a result of skillful pooling and blending of scientific knowledge and local time-and-place knowledge. Uncertainty reduction is costly and never fully accomplished. The uncertainty stemming from strategic behavior by the appropriators remains even after one acquires considerable knowledge about the resource system itself.

Given these levels of uncertainty about the basic structure of the problems appropriators face, the only reasonable assumption to make about the discovery and calculation processes employed is that appropriators engage in a considerable amount of trial-and-error learning. Many actions are selected without full knowledge of their consequences. Some dams wash out after the first heavy rains. Some rules cannot be enforced because no one is able to monitor conformance to them. By definition, trial-and-error methods involve error, perhaps even disasters. Over time, appropriators gain a more accurate understanding of the physical world and what to expect from the behavior of others.

Appropriators in many settings are strongly motivated to find better solutions to their problems if they can. The economic livelihood of the appropriators depends on their ingenuity in solving individual and joint problems. How complete and accurate the information local appropriators obtain about their situation will vary from one situation to another, depending on the number of appropriators involved, the complexity of the situation, and the stability of factors affecting individual behaviors and resource-system responses. The symmetry of information available to appropriators will also vary from situation to situation, depending on how expensive it is to acquire information and the rules used for disseminating information to appropriators.

Collective-action problems related to the provision of CPRs and appropriation from CPRs extend over time. Individuals attribute less value to benefits that they expect to receive in the distant future, and more value to those expected in the immediate future. In other words, individuals discount future benefits – how severely depends on several factors. Time horizons are affected by whether or not individuals expect that they or their children will be present to reap these benefits, as well as by opportunities they may have for more rapid returns in other settings. The dis-

count rates applied to future yields derived from a particular CPR may differ substantially across various types of appropriators. In a fishery, for example, the discount rates of local fishers who live in nearby villages will differ from the discount rates of those who operate the larger trawlers, who may fish anywhere along a coastline. The time horizons of the local fishers, in relation to the yield of the inshore fishery, extend far into the future. They hope that their children and their children's children can make a living in the same location. More mobile fishers, on the other hand, can go on to other fishing grounds when local fish are no longer available.

Discount rates are affected by the levels of physical and economic security faced by appropriators. Appropriators who are uncertain whether or not there will be sufficient food to survive the year will discount future returns heavily when traded off against increasing the probability of survival during the current year. Similarly, if a CPR can be destroyed by the actions of others, no matter what local appropriators do, even those who have constrained their harvesting from a CPR for many years will begin to heavily discount future returns, as contrasted with present returns.[8] Discount rates are also affected by the general norms shared by the individuals living in a particular society, or even a local community, regarding the relative importance of the future as compared with the present.

Discount rates are not the only aspects of human choice that are affected by shared norms of behavior. Although I stress the importance that the expected consequences will have on one's decisions, individuals vary in regard to the importance they place on acting in ways that they and others view as right and proper. Norms of behavior reflect valuations that individuals place on actions or strategies in and of themselves, not as they are connected to immediate consequences.[9] When an individual has strongly internalized a norm related to keeping promises, for example, the individual suffers shame and guilt when a personal promise is broken. If the norm is shared with others, the individual is also subject to considerable social censure for taking an action considered to be wrong by others.

Norms of behavior therefore affect the way alternatives are perceived and weighed. For many routine decisions, actions that are considered wrong among a set of individuals interacting together over time will not even be included in the set of strategies contemplated by the individual. If the individual's attention is drawn to the possibility of taking such an action by the availability of a very large payoff for doing so, the action may be included in the set of alternatives to be considered, but with a high cost attached. Actions that are strongly proscribed among a set of individuals will occur less frequently (even though they promise to yield high net

payoffs to individuals) than will those same actions in a community that does not censure such actions.

The most important impact that the type and extent of shared norms will have on the strategies available to individuals has to do with the level of opportunistic behavior that appropriators can expect from other appropriators. Opportunism is defined as "self-interest with guile" (Williamson 1975). In a setting in which few individuals share norms about the impropriety of breaking promises, refusing to do one's share, shirking, or taking other opportunistic actions, each appropriator must expect all other appropriators to act opportunistically whenever they have the chance. In such a setting it is difficult to develop stable, long-term commitments. Expensive monitoring and sanctioning mechanisms may be needed. Some long-term arrangements that once were productive are no longer feasible, given their costs of enforcement. In a setting in which there are strong norms against opportunistic behavior, each appropriator will be less wary about the dangers of opportunism.

In every group there will be individuals who will ignore norms and act opportunistically when given a chance. There are also situations in which the potential benefits will be so high that even strongly committed individuals will break norms. Consequently, the adoption of norms of behavior will not reduce opportunistic behavior to zero. Opportunistic behavior is a possibility that must be dealt with by all appropriators trying to solve CPR problems.

In some settings, however, rampant opportunistic behavior severely limits what can be done jointly without major investments in monitoring and sanctioning arrangements. Substantial benefits have to be obtained to make costly monitoring and sanctioning activities worthwhile. In other settings, long-term joint commitments can be undertaken with only a modest investment in monitoring and sanctioning arrangements. Shared norms that reduce the cost of monitoring and sanctioning activities can be viewed as social capital to be utilized in solving CPR problems.

Because CPR settings extend over time, and individuals adopt internal norms, it is possible for individuals to utilize contingent strategies, not simply independent strategies, in relating to one another. By "contingent strategies" I mean a whole class of planned actions that are contingent on conditions in the world. The contingent strategy that has been the object of the most scholarly attention is tit for tat in a two-person game in which an individual adopts a cooperative action in the first round and then mimics the action of the opponent in future rounds (Axelrod 1981, 1984). There are many other contingent strategies that can be adopted; they vary

in terms of the level of initial cooperation extended and the actions of others required for switching behavioral patterns. That individuals utilize contingent strategies in many complex and uncertain field settings is an important foundation for later analysis.

Thus, I use a very broad conception of rational action, rather than a narrowly defined conception. The internal world of individual choice that I use is illustrated in Figure 2.1. Four internal variables – expected benefits, expected costs, internal norms, and discount rates – affect an individual's choice of strategies. Individuals selecting strategies jointly produce outcomes in an external world that impinge on future expectations concerning the benefits and costs of actions. What types of internal norms an individual possesses are affected by the shared norms held by others in regard to particular types of situations. Similarly, internal discount rates are affected by the range of opportunities that an individual has outside any particular situation.

This general model of individual choice is thus open to many particular specifications. The particular assumptions made about the completeness, shape, and differentiability of preference functions depend on the situation of relevance for a particular model in this theory. In simple, highly constrained situations where individuals have interacted for long periods of time, assumptions about convex, twice-differentiable preference functions

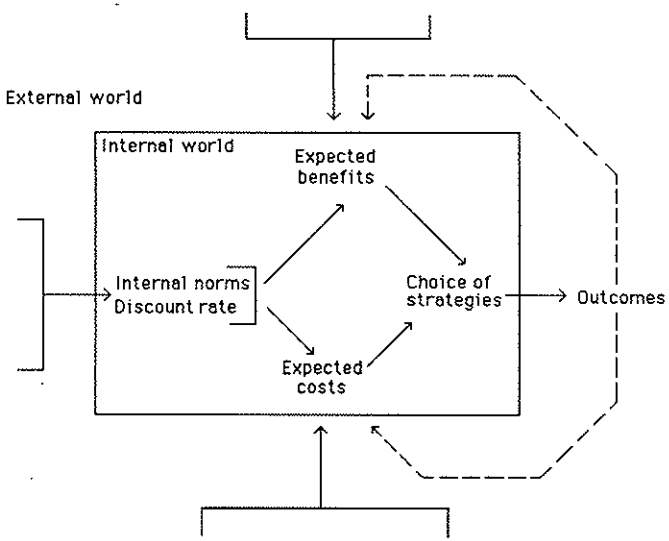

Figure 2.1. The internal world of individual choice.

may be appropriate. In complex situations involving unstructured problems, assuming complete preference functions of any shape is not meaningful. The most one can say is that the individuals in such situations are engaged in a trial-and-error effort to learn more about the results of their actions so that they can evaluate benefits and costs more effectively over time.

This general conception is one way of fulfilling Popper's advice to make the rationality principle "an almost empty principle" (Popper 1967). It places the primary weight of theoretical analysis on specifying rigorously and fully the models of the situations in which individuals find themselves. It accepts Popper's methodological advice to emphasize the way we describe the situations in which individuals find themselves so that we can use observable variables to reject our theories, rather than internal, in-the-mind, subjective variables, which are far more difficult to measure.

Thus, most of the analysis contained in this volume examines the combinations of situational variables that are most likely to affect individuals' choices of strategies and how those situational variables occur.

INTERDEPENDENCE, INDEPENDENT ACTION, AND COLLECTIVE ACTION

When multiple appropriators are dependent on a given CPR as a source of economic activity, they are jointly affected by almost everything they do. Each individual must take into account the choices of others when assessing personal choices. If one fisher occupies a good fishing site, a second fisher arriving at the same location must invest more resources to travel to another site, or else fight for the first site. If one irrigator allocates time and materials to repairing a broken control gate in an irrigation canal, all other irrigators using that canal are affected by that action, whether or not they want the control gate fixed and whether or not they contribute anything to the repair. The key fact of life for coappropriators is that they are tied together in a lattice of interdependence so long as they continue to share a single CPR. The physical interdependence does not disappear when effective institutional rules are utilized in the governance and management of the CPR. The physical interdependence remains; what changes is the result the appropriators obtain.

When appropriators act independently in relationship to a CPR generating scarce resource units, the total net benefits they obtain usually will be less than could have been achieved if they had coordinated their strategies in some way. At a minimum, the returns they receive from their appropriation efforts will be lower when decisions are made independently than they

would have been otherwise. At worst, they can destroy the CPR itself. As long as the appropriators stay "unorganized," they cannot achieve a joint return as high as they could have received if they had organized in some way to undertake collective action. Mancur Olson stated the key problem facing appropriators who rely on a single CPR:

> . . . when a number of individuals have a common or collective interest – when they share a single purpose or objective – individual, *unorganized* action [either will] not be able to advance that common interest at all, or will not be able to advance that interest adequately. (Olson 1965, p. 7; emphasis added)

Prisoners who have been placed in separate cells and cannot communicate with one another are also in an interdependent situation in which they must act independently. Acting independently in this situation is the result of coercion, not its absence. The herders in Hardin's model also act independently. Each decides on the number of animals to put on the meadow without concern for how that will affect the actions chosen by others.

At the most general level, the problem facing CPR appropriators is one of organizing: how to change the situation from one in which appropriators act independently to one in which they adopt coordinated strategies to obtain higher joint benefits or reduce their joint harm. That does not necessarily mean creating an organization. Organizing is a process; an organization is the result of that process. An organization of individuals who constitute an ongoing enterprise is only one form of organization that can result from the process of organizing.

The core of organization involves changes that order activities so that sequential, contingent, and frequency-dependent decisions are introduced where simultaneous, noncontingent, and frequency-independent actions had prevailed.[10] Almost all organization is accomplished by specifying a sequence of activities that must be carried out in a particular order.[11] Because of the repeated situations involved in most organized processes, individuals can use contingent strategies in which cooperation will have a greater chance of evolving and surviving. Individuals frequently are willing to forgo immediate returns in order to gain larger joint benefits when they observe many others following the same strategy. By requiring the participation of a minimal set of individuals, organizations can draw on this frequency-dependent behavior to obtain willing contributions on the part of many others. Changing the positive and negative inducements associated with particular actions and outcomes and the levels and types of information available can also encourage coordination of activities.[12]

Unlike prisoners, most CPR appropriators are not coerced into acting independently. Making the switch, however, from independent to co-

ordinated or collective action is a nontrivial problem. The costs involved in transforming a situation from one in which individuals act independently to one in which they coordinate activities can be quite high. And the benefits produced are shared by all appropriators, whether or not they share any of the costs of transforming the situation. Empirically, we know that some appropriators are able to solve this problem, and some are not. Theoretically, we do not have a coherent explanation for why some succeed and others fail.

The theory of the firm and the theory of the state can each provide an explanation for one way in which collective action can be achieved. Each involves the creation of a new institutional arrangement in which the rules in use are fundamentally different from those that structure independent action. Let us briefly and in a stylized fashion consider how each theory can "solve" the problem of independent action in an interdependent situation. By doing this, we can better illustrate the absence of a similar theory that would identify the mechanisms by which a group of individuals could organize themselves.

The theory of the firm

In the theory of the firm, an entrepreneur recognizes an opportunity to increase the return that can be achieved when individuals are potentially involved in an interdependent relationship.[13] The entrepreneur then negotiates a series of contracts with various participants that specify how they are to act in a coordinated, rather than independent, fashion. Each participant voluntarily chooses whether or not to join the firm, but gives up to the entrepreneur discretion over some range of choices. The participants become the agents of the entrepreneur. After paying each of the agents, the entrepreneur retains residual profits (or absorbs losses).

Consequently, the entrepreneur is highly motivated to organize the activity in a manner as efficient as possible. The entrepreneur attempts to craft contracts with agents that will induce them to act so as to increase the returns to the entrepreneur, and the entrepreneur monitors the agents' performances. The entrepreneur can terminate the contract of an agent who does not perform to the satisfaction of the entrepreneur. Because agents freely decide whether or not to accept the terms of the entrepreneur's contract, the organization is considered private, voluntary, and, at least by some individuals, nonexploitative. If there are large residuals to be obtained, however, it is the entrepreneur, not the agents, who receives them.[14] When a firm is located in an open market, one can presume that

external competition will pressure the entrepreneur toward developing efficient internal institutions.

The theory of the state

The theory of the state can also be presented in a brief and stylized version. Instead of an entrepreneur, we posit a ruler who recognizes that substantial benefits can be obtained by organizing some activities. As Hobbes first formulated the theory, individuals who independently engage in protection activities overinvest in weapons and surveillance and consequently live in constant fear. If a ruler gains a monopoly on the use of force, the ruler can use coercion as the fundamental mechanism to organize a diversity of human activities that will produce collective benefits. The ruler obtains taxes, labor, or other resources from subjects by threatening them with severe sanctions if they do not provide the resources.

The "wise" ruler uses the resources thus obtained to increase the general level of economic well-being of the subjects to a degree sufficient that the ruler can increase tax revenues while being able to reduce the more oppressive uses of coercion. Rulers, like entrepreneurs, keep the residuals. Subjects, like agents, may be substantially better off as a result of subjecting themselves to the coercion exercised by rulers. If the effort is highly successful, the ruler captures a substantial portion of the surplus.[15] There is no mechanism, such as a competitive market, that would exert pressure on the ruler to design efficient institutions. The ruler may face rebellion if the measures selected are too repressive, or military defeat if the realm is not adequately organized to do well in warfare.

In both the theory of the firm and the theory of the state, the burden of organizing collective action is undertaken by one individual, whose returns are directly related to the surplus generated. Both involve an outsider taking primary responsibility for supplying the needed changes in institutional rules to coordinate activities. The entrepreneur or the ruler makes credible commitments to punish anyone who does not follow the rules of the firm or the state. Because they gain the residuals, it is in their interest to punish nonconformance to their rules if they are confronted with nonconformance. Consequently, their threats to punish are credible (Schelling 1960; Williamson 1983). It is also in their interest to monitor the actions of agents and subjects to be sure they conform to prior agreements. Both theories thus address how a new institutional arrangement can come about, how credible commitments can be made, and why monitoring must be supplied.[16]

THREE PUZZLES: SUPPLY, COMMITMENT, AND MONITORING

Although the theory of the firm and the theory of the state can resolve these problems, no equivalently well developed and generally accepted theory provides a coherent account for how a set of principals, faced with a collective-action problem, can solve (1) the problem of supplying a new set of institutions, (2) the problem of making credible commitments, and (3) the problem of mutual monitoring.

The problem of supply

In a recent commentary on contractarianism and the new institutionalism, Robert Bates (1988) raises the issue that modern institutional theories do not adequately address the problem of supply. As he points out, "the new institutionalism is contractarian in spirit. Institutions are demanded because they enhance the welfare of rational actors. The problem is: Why are they supplied?" Bates first examines assurance games, where suppling new rules is considered easier to accomplish than it is in PD games, because there are mutually beneficial outcomes that are potential equilibria in the sense that once reached, no one has an incentive independently to switch strategies. Equilibria in assurance games do not, however, necessarily reward participants equally. Participants prefer a set of rules that will give them the most advantageous outcome. Although all will prefer a new institution that will enable them to coordinate their activities to achieve one of these equilibria, in contrast to continuing their independent actions, a fundamental disagreement is likely to arise among participants regarding which institution to choose. "The proposed solution to coordination – or assurance – games thus itself constitutes a collective dilemma" (Bates 1988, p. 394).[17]

Bates then turns to problems faced by a set of symmetric principals facing a collective dilemma in which all would benefit from a change in rules. Because supplying a new set of rules is the equivalent of providing another public good, the problem faced by a set of principals is that obtaining these new rules is a second-order collective dilemma.

> Even if the payoffs were symmetric and all persons were made [equally] better off from the introduction of the institutions, there would still be a failure of supply, since the institution would provide a collective good and rational individuals would seek to secure its benefits for free. The incentives to free-ride would undermine the incentives to organize a solution to the collective dilemma. It is subject to the very incentive problems it is supposed to resolve.
>
> (Bates 1988, pp. 394–5)

Because Bates presumes that the second-order dilemma is no easier to solve than the initial dilemma, he concludes that a new set of rules to solve the collective dilemma will not be provided by a set of principals (M. Taylor 1987).

Bates finds this deeply puzzling as it is obvious to him that some individuals in field settings *do* solve the problem of supply. Bates wishes to remain an institutionalist and a rational-choice theorist. His approach to addressing the inadequacy of current theories to explain how individuals supply their own rules is to turn for inspiration to some of the recent work in the theory of repeated games under uncertainty. Kreps and associates (1982) have demonstrated that in a finitely repeated PD game, some uncertainty about the exact payoff to a player can produce cooperative equilibria, as well as many other equilibria. Given this, it will pay one player to signal to other players an intention to cooperate, in the hope that they will reciprocate for a series of mutually productive plays. Thus, establishing trust and establishing a sense of community are, in Bates's view, mechanisms for solving the problem of supplying new institutions.

> Driven by a concern with institutions, we re-enter the world of the behavioralists. But we do so not in protest against the notion of rational choice, but rather in an effort to understand how rationality on the part of individuals leads to coherence at the level of society. (Bates 1988, p. 399)

Bates's approach is similar to the approach taken in this volume.

The problem of credible commitment

A second puzzle to be solved in explaining how a set of principals can organize themselves to obtain long-term collective benefits is the problem of commitment.[18] To understand the heart of the "commitment" problem, let us consider a highly simplified picture of the choices available to appropriators in CPR situations.[19] In all cases in which individuals have organized themselves to solve CPR problems, rules have been established by the appropriators that have severely constrained the authorized actions available to them. Such rules specify, for example, how many resource units an individual can appropriate, when, where, and how they can be appropriated, and the amounts of labor, materials, or money that must be contributed to various provisioning activities. If everyone, or almost everyone, follows these rules, resource units will be allocated more predictably and efficiently, conflict levels will be reduced, and the resource system itself will be sustained over time.

During an initial time period, an appropriator, calculating his or her

estimated future flow of benefits if most appropriators agree to follow a proposed set of rules, may agree to abide by the set of rules in order to get others to agree. During later time periods, the immediate return to the appropriator for breaking one or another of the rules frequently can be high. When an irrigator's crops are severely stressed, the financial benefit of taking water "out of turn" can be substantial. Breaking the rules may save an entire crop from drought. On many occasions after an initial agreement to a set of rules, each appropriator must make further choices. Minimally, the choice at each decision time subsequent to the agreement can be thought of as the choice between complying to a set of rules, C_t, or breaking the set of rules in some fashion, B_t. On many occasions, B_t will generate a higher immediate return for the appropriator than will C_t, unless B_t is detected and a sanction, S, is imposed that makes $C_t > B_t - S$.[20]

At the beginning of the process, all appropriators know the general configuration of the commitment problem. If they wish to change their appropriation rules, for example, to rotate the authority to withdraw water from an irrigation system among authorized appropriators, how does one appropriator credibly commit himself or herself to follow a rotation system when everyone knows that the temptation to break that commitment will be extremely strong in future time periods? Each appropriator can pledge: "I will keep my commitment if you keep yours." But when the temptation arises, how do past commitments bind the appropriator to future sacrifices? And given that it may be possible to steal water without being observed, how do the other appropriators know that commitments are actually being kept? No one wants to be a "sucker," keeping a promise that everyone else is breaking.

External coercion is a frequently cited theoretical solution to the problem of commitment (Schelling 1984). The presumption is made that if individuals commit themselves to a contract whereby a stiff sanction ($S > B_{max}$) will be imposed by an external enforcer to ensure compliance during all future time periods, then each can make a credible commitment and obtain benefits that would not otherwise be attainable. External coercion is at times a sleight-of-hand solution, because the theorist does not address what motivates the external enforcer to monitor behavior and impose sanctions. That is not, however, the issue at hand; it will be discussed later. The immediate issue is that a self-organized group must solve the commitment problem without an external enforcer. They have to motivate themselves (or their agents) to monitor activities and be willing to impose sanctions to keep conformance high.

These puzzles cumulate. Even if one appropriator took the time and effort to analyze the problems they faced and to devise a set of rules that

could improve their joint returns, the effort at supply would be pointless unless the appropriators could commit themselves to follow the rules. Unless the monitoring problem can be solved, credible commitments cannot be made. So let us now address the problem of mutual monitoring.

The problem of mutual monitoring

The question of how a set of principals can engage in mutual monitoring of conformance to a set of their own rules is not easily addressed within the confines of collective-action theory. In fact, the usual theoretical prediction is that they will not do so. The usual presumption that individuals will not themselves monitor a set of rules, even if they have devised those rules themselves, was summarized by Jon Elster in a recent discussion of the motivations for workers to monitor each other's participation in a union:

> Before a union can force or induce workers to join it must overcome a free-rider problem in the first place. To assume that the incentives are offered in a decentralized way, by mutual monitoring, gives rise to a second-order free-rider problem. Why, for instance, should a rational, selfish worker ostracize or otherwise punish those who don't join the union? What's in it for him? True, it may be better for all members if all punish non-members than if none do, but for each member it may be even better to remain passive. Punishment almost invariably is costly to the punisher, while the benefits from punishment are diffusely distributed over the members. It is, in fact, a public good: To provide it, one would need second-order selective incentives which would, however, run into a third-order free-rider problem. (Elster 1989, pp. 40–1)[21]

Dilemmas nested inside dilemmas appear to be able to defeat a set of principals attempting to solve collective-action problems through the design of new institutions to alter the structure of the incentives they face. Without monitoring, there can be no credible commitment; without credible commitment, there is no reason to propose new rules. The process unravels from both ends, because the problem of supply is presumed unsolvable in the first place. But some individuals have created institutions, committed themselves to follow rules, and monitored their own conformance to their agreements, as well as their conformance to the rules in a CPR situation. Trying to understand how they have done this is the challenge of this study.

FRAMING INQUIRY

Understanding how individuals solve particular problems in field settings requires a strategy of moving back and forth from the world of theory to the world of action. Without theory, one can never understand the general

underlying mechanisms that operate in many guises in different situations. If not harnessed to solving empirical puzzles, theoretical work can spin off under its own momentum, reflecting little of the empirical world.

When theoretical predictions and empirical observations are inconsistent, adjustments in theory are needed.[22] Predictions that individuals will not devise, precommit to, and monitor their own rules to change the structure of interdependent situations so as to obtain joint benefits are inconsistent with evidence that some individuals have overcome these problems, though others have not.

Theories affect the way that a problem is framed, not simply the particular assumptions used in an explanation. The way a problem is framed affects which questions are asked and what one looks for in conducting empirical inquiries. Several of the presumptions that have framed the way that scholars have approached the analysis of collective action have led them to an overly pessimistic view of the capacity of individuals to restructure their own interdependent situations.

Scholars addressing the problem of collective action frequently presume (1) that the underlying structure is always that of a PD game and (2) that one level of analysis is sufficient. When CPR problems are conceptualized as collective-action problems – a useful way to think of them – these same presumptions continue to frame the analyses, leading to the policy prescriptions described in Chapter 1. Consequently, part of the strategy pursued in this inquiry is to start from an alternative set of initial presumptions:

1 Appropriators in CPR situations face a variety of appropriation and provision problems whose structures vary from one setting to another, depending on the values of underlying parameters.

2 Appropriators must switch back and forth across arenas and levels of analysis.

These presumptions lead me to examine questions in a manner somewhat different from that of an analyst using the "normal" presuppositions of collective-action theory, although I still rely heavily on the work of other scholars.

Appropriation and provision problems

Although some interdependent CPR situations have the structure of a PD game, many do not. Several scholars have shown how some simple situations facing appropriators may be better characterized as "assurance" games and as the game known as "chicken" (Runge 1981, 1984a; M.

Taylor 1987; M. Taylor and Ward 1982). The underlying problem facing the appropriators in the Alanya fishing grounds discussed in Chapter 1 cannot be represented as a PD game. A formal analysis shows that it has the structure of an "assignment" game (Gardner and E. Ostrom 1990). In many irrigation systems similar to those discussed in Chapter 3, the fundamental choices facing appropriators are whether or not to steal water and whether or not to monitor the behaviors of others who might be stealing. The resulting game structure is complex and does not reduce down to any simple game. It does not have a single equilibrium. The amounts of stealing and monitoring that occur will depend on the values of parameters such as the number of appropriators, the cost of monitoring, the benefit from stealing, the punishment imposed when stealing is discovered, and the reward that a monitor receives for detecting a rule-breaker (Weissing and E. Ostrom 1990).

Consequently, instead of presuming that all CPR situations involve one underlying structure, I presume that the appropriators relying on any CPR face a variety of problems to be solved. The structure of these problems will depend on the values of underlying parameters, such as the value and predictability of the flow of resource units, the ease of observing and measuring appropriator activities, and so forth. In an effort to develop a unified framework within which to organize the analysis of CPR situations using the tools of game theory and institutional analysis and the findings from empirical studies in laboratory and field settings, Roy Gardner, James Walker, and I have found it most useful to cluster the problems facing CPR appropriators into two broad classes: appropriation problems and provision problems (Gardner et al. 1990).

When appropriators face appropriation problems, they are concerned with the effects that various methods of allocating a fixed, or time-independent, quantity of resource units will have on the net return obtained by the appropriators. Provision problems concern the effects of various ways of assigning responsibility for building, restoring, or maintaining the resource system over time, as well as the well-being of the appropriators. Appropriation problems are concerned with the allocation of the flow; provision problems are concerned with the stock. Appropriation problems are time-independent; provision problems are time-dependent. Both types of problems are involved in every CPR to a greater or lesser extent, and thus the solutions to one problem must be congruent with solutions to the other. The structure of an appropriation problem or a provision problem will depend on the particular configuration of variables related to the physical world, the rules in use, and the attributes of the individuals involved in a specific setting.

Appropriation problems. In regard to appropriation, the key problem in a CPR environment is how to allocate a fixed, time-independent quantity of resource units so as to avoid rent dissipation and reduce uncertainty and conflict over the assignment of rights. Rents are dissipated whenever the marginal returns from an appropriation process are smaller than the marginal costs of appropriation. Rent dissipation can occur because too many individuals are allowed to appropriate from the resource, because appropriators are allowed to withdraw more than the economically optimal quantity of resource units, or because appropriators overinvest in appropriation equipment (e.g., fishing gear).

In an open-access[23] CPR, in which no limit is placed on who can appropriate, the time-independent appropriation process frequently can be characterized as a PD game.[24] Rent dissipation is likely to be endemic. No appropriator has any incentive to leave any resource units for other appropriators to harvest (Gordon 1954; Scott 1955). In a limited-access CPR, in which a well-defined group of appropriators must jointly rely on a CPR for access to resource units, the incentives facing the appropriators will depend on the rules governing the quantity, timing, location, and technology of appropriation and how these are monitored and enforced. The structure of a limited-access CPR is not a PD game (Dasgupta and Heal 1979, p. 59) and lacks a dominant strategy for each participant. The incentives of appropriators who act independently, however, will lead them to overinvest in any input factor that is not constrained under the current rules (Townsend and Wilson 1987).

A second type of appropriation problem relates to assignment of spatial or temporal access to the resource. This occurs because spatial and temporal distributions of resource units frequently are heterogeneous and uncertain. Many fishing grounds, such as Alanya, are characterized by "fishing sites" that vary in their productivity. In grazing areas, one region may be drowned out in one year, but lush with growth in another year. Farmers who extract water from the head of an irrigation system can obtain more water than farmers who are located at the tail end. The risks associated with geographic or temporal uncertainty can be very high. Physical works, particularly those with storage, involve somewhat reduced risks, but well-enforced rules to allocate time or location of use or the quantity of resource units to specific users can reduce risks still further if the rules are well crafted to fit the physical attributes of the resource system. If risks are sufficiently reduced, appropriators can invest in productive enterprises that would not otherwise be economically viable. Physical violence occurring among the users of fisheries and irrigation systems is symptomatic of inadequate assignments of spatial or temporal slots to appropriators. When

appropriators consider the assignment of access rights and duties to be unfair, uneconomic, uncertain, or inappropriately enforced, that can adversely affect their willingness to invest in provision activities. The particular rules used to regulate appropriation will affect monitoring and policing costs and the type of strategic behavior that will occur between appropriators and monitors (the detection/deterrence game).[25]

Provision problems. Analyses of provision problems focus on the time-dependent, productive nature of investment in the resource itself. Provision problems may occur on the supply side, on the demand side, or on both sides. The supply-side problem faced in a CPR environment is related to the construction of the resource itself and its maintenance. Construction problems are like any long-term investment in capital infrastructure. Maintenance problems involve determining the type and level of regular maintenance (and reserves for emergency repair) that will sustain the resource system over time. Given that an investment in maintenance will affect the future rate at which a capital infrastructure will deteriorate, decisions about these activities are difficult to make even when a single entrepreneur makes them. When this difficult long-term problem is combined with the free-riding incentives of multiple appropriators, we see that organizing to maintain a system is a challenging task.

Supply-side provision problems are similar to the supply-side problems in providing a continuing, rather than a one-shot, public good. If appropriators act independently, they can expect that less than an optimal effort will be devoted to the construction, and particularly to the maintenance, of the system because of free-riding. What makes the problem more difficult in a CPR situation than in a public-goods situation is that unless appropriation problems are resolved, the provision problems may prove intractable. In a public-goods situation, appropriation problems do not exist, because resource units are not subtractable.

Demand-side provision problems involve regulating withdrawal rates so that they do not adversely affect the resource itself. Many of the dynamic models of "rent dissipation" in the fisheries literature (Clark 1980; Clark, Munro, and Charles 1985) have focused on the time-dependent relationship between current withdrawals and future yields. The same rules that affect the allocation of this year's resource units will have an impact on the availability of resource units next year and the years thereafter.

The underlying uniformities of all CPR situations relate to the nonseparability of one's choice of strategy and the choices made by others, as well as the fact that solving provision problems depends on achieving

adequate solutions to appropriation problems, not the particular game-theoretical representations for these commonalities.[26] Many factors affect the strategic structure of a particular appropriation or provision problem, including the physical structure of a particular CPR, the technology available to the appropriators, the economic environment, and the sets of rules that affect the incentives that appropriators face. As Oliver (1980, p. 1,359) stressed after reviewing many of the efforts to present "the" model of collective action, "there is no one 'right' way to model collective action: different models imply different assumptions about the situation and lead to substantively different conclusions."

Multiple levels of analysis

Most current analyses of CPR problems and related collective-action problems focus on a single level of analysis – what can be called the operational level of analysis (Kiser and E. Ostrom 1982). At the operational level of analysis, one assumes that both the rules of the game and the physical, technological constraints are given and will not change during the time frame of analysis: The actions of individuals in an operational situation directly affect the physical world. Resource units are withdrawn from a CPR. Inputs are transformed into outputs. Goods are exchanged. Appropriation and provision problems occur at an operational level. When doing an analysis of an operational situation, it is necessary for the analyst to assume that the technology and the institutional rules are known and unchanging. Both technology and rules are, however, subject to change over time. Analysis of technological changes has proved to be far more difficult than analysis of production and consumption decisions within a fixed technology (Dosi 1988; Nelson and Winter 1982). Analysis of institutional change is also far more difficult than analysis of operational decisions within a fixed set of rules.[27] The rules affecting operational choice are made within a set of collective-choice rules that are themselves made within a set of constitutional-choice rules. The constitutional-choice rules for a micro-setting are affected by collective-choice and constitutional-choice rules for larger jurisdictions. Individuals who have self-organizing capabilities switch back and forth between operational-, collective-, and constitutional-choice arenas, just as managers of production firms switch back and forth between producing products within a set technology, introducing a new technology, and investing resources in technology development. Given that CPR appropriators in some of the cases to be discussed in this volume do switch back and forth between arenas, we must drop the framing assumption that analysis at a single level will be sufficient. It is also essential to clarify what is meant by "institutions" in the first place.

"Institutions" can be defined as the sets of working rules that are used to determine who is eligible to make decisions in some arena, what actions are allowed or constrained, what aggregation rules will be used, what procedures must be followed, what information must or must not be provided, and what payoffs will be assigned to individuals dependent on their actions (E. Ostrom 1986a). All rules contain prescriptions that forbid, permit, or require some action or outcome. Working rules are those actually used, monitored, and enforced when individuals make choices about the actions they will take (Commons 1957). Enforcement may be undertaken by others directly involved, agents they hire, external enforcers, or any combination of these enforcers. One should not talk about a "rule" unless most people whose strategies are affected by it know of its existence and expect others to monitor behavior and to sanction nonconformance. In other words, working rules are common knowledge and are monitored and enforced. Common knowledge implies that every participant knows the rules, and knows that others know the rules, and knows that they also know that the participant knows the rules.[28] Working rules are always monitored and enforced, to some extent at least, by those directly involved. In any repetitive situation, one can assume that individuals come to know, through experience, good approximations of the levels of monitoring and enforcing involved.

Working rules may or may not closely resemble the formal laws that are expressed in legislation, administrative regulations, and court decisions. Formal law obviously is a major source of working rules in many settings, particularly when conformance to them is actively monitored and sanctions for noncompliance are enforced. When one speaks about a system that is governed by a "rule of law," this expresses the idea that formal laws and working rules are closely aligned and that enforcers are held accountable to the rules as well as others. In many CPR settings, the working rules used by appropriators may differ considerably from legislative, administrative, or court regulations (Wade 1988). The difference between working rules and formal laws may involve no more than filling in the lacunae left in a general system of law. More radically, operational rules may assign de facto rights and duties that are contrary to the de jure rights and duties of a formal legal system. My primary focus in this study will be on the de facto rules actually used in CPR field settings, in an effort to understand the incentives and consequences they produce.

All rules are nested in another set of rules that define how the first set of rules can be changed.[29] This nesting of rules within rules at several levels is similar to the nesting of computer languages at several levels. What can be done at a higher level will depend on the capabilities and limits of the

software (rules) at that level, on the software (rules) at a deeper level, and on the hardware (the CPR). Whenever one addresses questions about *institutional change*, as contrasted to action within institutional constraints, it is essential to recognize the following:

1 Changes in the rules used to order action at one level occur within a currently "fixed" set of rules at a deeper level.

2 Changes in deeper-level rules usually are more difficult and more costly to accomplish, thus increasing the stability of mutual expectations among individuals interacting according to a set of rules.

It is useful to distinguish three levels of rules that cumulatively affect the actions taken and outcomes obtained in using CPRs (Kiser and E. Ostrom 1982). *Operational rules* directly affect the day-to-day decisions made by appropriators concerning when, where, and how to withdraw resource units, who should monitor the actions of others and how, what information must be exchanged or withheld, and what rewards or sanctions will be assigned to different combinations of actions and outcomes. *Collective-choice rules* indirectly affect operational choices. These are the rules that are used by appropriators, their officials, or external authorities in making policies – the operational rules – about how a CPR should be managed. *Constitutional-choice rules* affect operational activities and results through their effects in determining who is eligible and determining the specific rules to be used in crafting the set of collective-choice rules that in turn affect the set of operational rules. One can think of the linkages among these rules and the related level of analysis at which humans make choices and take actions, as shown in Figure 2.2. The processes of appropriation, provision, monitoring, and enforcement occur at the operational level. The processes of policy-making, management, and adjudication of policy decisions occur at the collective-choice level. Formulation, governance, adjudication, and modification of constitutional decisions occur at the constitutional level.[30]

This nesting of rules within rules is the source of considerable confusion and debate. Institutional theorists, who have attempted to make the choice of rules endogenous to an analysis, have been criticized because it is necessary to assume the presence of some rules that govern the choice of other rules.[31] Making the choice of operational-level rules endogenous does not imply making the choice of collective-choice or constitutional-choice rules endogenous at the same time. For purposes of analysis, the theorist has to assume that some rules already exist and are exogenous for purposes of a particular analysis. The fact that they are held constant and unchanging

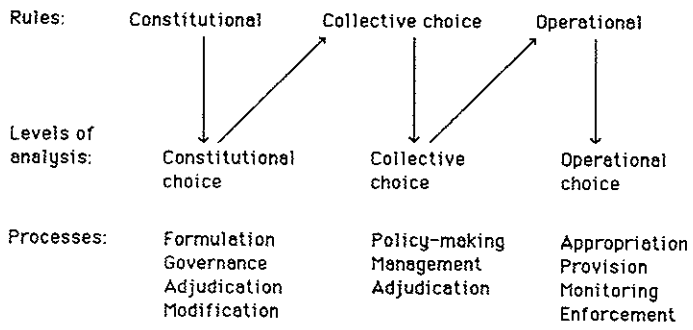

Figure 2.2. Linkages among rules and levels of analysis.

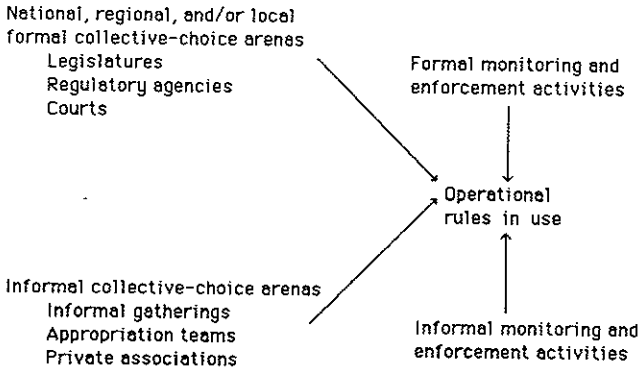

Figure 2.3. Relationships of formal and informal collective-choice arenas and CPR operational rules.

during analysis, however, does not mean that they cannot be changed. Those very same rules may themselves be the objects of choice in a separate analysis or in the context of a different area of choice. At the end of every season, for example, intercollegiate sports leagues consider whether or not to alter the rules of the game for the next season.

On the other hand, rules are changed less frequently than are the strategies that individuals adopt within the rules. Changing the rules at any level of analysis will increase the uncertainty that individuals will face. Rules provide stability of expectations, and efforts to change rules can rapidly

reduce that stability. Further, it is usually the case that operational rules are easier to change than collective-choice rules, and collective-choice rules are easier to change than constitutional-choice rules. Analyses of deeper layers of rules are more difficult for scholars and participants to make. Deciding whether an irrigation association should use a legislative body of five or nine members will depend on the physical and historical environment and the analyst's speculation about different outcomes at several levels.[32]

When doing analysis at any one level, the analyst keeps the variables of a deeper level fixed for the purpose of analysis. Otherwise, the structure of the problem would unravel. But self-organizing and self-governing individuals trying to cope with problems in field settings go back and forth across levels as a key strategy for solving problems. Individuals who have no self-organizing and self-governing authority are stuck in a single-tier world. The structure of their problems is given to them. The best they can do is to adopt strategies within the bounds that are given.

At each level of analysis there may be one or more arenas in which the types of decisions made at that level will occur. The concept of an "arena" does not imply a formal setting, but can include such formal settings as legislatures and courts. An arena is simply the situation in which a particular type of action occurs. Policy-making regarding the rules that will be used to regulate operational-level choices is carried out in one or more collective-choice arenas. If the appropriators using a CPR change at least some of the working rules used to organize appropriation and provision, the arena in which collective-choice decisions will be made may be a local coffeehouse, the meetings of a producers' co-op, or the meetings of an organization that has been set up specifically for the purpose of managing and governing this CPR and possibly others related to it. If the appropriators using a CPR cannot change the rules used to organize operational choices, then the only arenas for collective choice are external to the CPR appropriators. In such cases, choices about the rules to be used will be made by government officials in bureaucratic structures, by elected representatives in local or national legislatures, and by judges in judicial arenas.

The relationships among arenas and rules rarely involve a single arena related to a single set of rules. Most frequently, several collective-choice arenas affect the set of operational rules actually used by appropriators for making choices about harvesting and investment strategies in a CPR. Decisions made in national legislatures and courts concerning access to all resources of particular types, when given legitimacy in a local setting and enforced, are likely to affect the operational rules actually used in particular locations. The relationships among formal and informal collective-choice arenas and the resulting operational rules are illustrated in Figure

2.3. Similarly, formal and informal constitutional-choice processes may occur in local, regional, and/or national arenas.

That the working rules used by appropriators may have multiple sources, and may include de facto as well as de jure rules, greatly complicates the problem of understanding behaviors and outcomes in particular locations and the problem of improving outcomes. The absence of national, formal laws regulating the appropriation from and provision of a CPR is not equivalent to the absence of effective rules. Over a long period of time, local appropriators may have developed working rules that constrain the entry to and use of a CPR. Such rules may or may not lead appropriators to manage their resource efficiently and fairly, but they will affect the strategies that appropriators perceive to be available to them and the resulting outcomes.

STUDYING INSTITUTIONS IN FIELD SETTINGS

In the cases described in Chapters 3, 4, and 5, I present only a fraction of the detailed information to be found in the in-depth case studies from which I draw. A reader is justified in wanting to know how I approach the task of reading in-depth case materials and abstracting from them for the purpose of studying how individuals supply their own institutions, how they commit themselves to conform to their own rules, and how they monitor each other's conformance to these rules. In general, I am relying on the method of institutional analysis that has been described elsewhere (Kiser and E. Ostrom 1982; Oakerson 1986; E. Ostrom 1986a,b) and applied in many papers, doctoral dissertations, and books (Blomquist 1988a–d; Gardner and E. Ostrom 1990; Kaminski 1992; V. Ostrom [1973] 2008; V. Ostrom, Feeny, and Picht 1988; Sawyer 1989; Schaaf 1989; Tang 1989; Wynne 1988; Yang 1987).

The basic strategy is to identify those aspects of the physical, cultural, and institutional setting that are likely to affect the determination of who is to be involved in a situation, the actions they can take and the costs of those actions, the outcomes that can be achieved, how actions are linked to outcomes, what information is to be available, how much control individuals can exercise, and what payoffs are to be assigned to particular combinations of actions and outcomes. Once one has all the needed information, one can then abstract from the richness of the empirical situation to devise a playable game that will capture the essence of the problems individuals are facing.

To solve appropriation and provision problems, for example, individuals must learn about the structure of the physical system on which they jointly rely, about their own appropriation and use patterns, about the norms of

behavior that are followed in a community, about the incentives they will encourage or discourage as they change rules, and about how all of these factors will cumulatively affect their net benefits and costs over time. Individuals must assess what types of transactions costs will be involved in adopting various strategies within a set of rules or in changing those rules. If the analyst is to understand the structure of the situation, the analyst must learn about the same set of variables.

For the cases that I discuss in Chapter 3, I do not know what the structures of the situations were like before some appropriators in the mists of time began to experiment with various rules to allocate resource units and provisioning responsibilities. What I do know is that the appropriators in the "success" cases described in Chapter 3 were able to allocate resource units and at the same time avoid the conflict, uncertainty, and perceived unfairness of a poorly solved assignment problem, the overinvestment in appropriation efforts involved in an inadequately solved rent-dissipation problem, or the deterioration or destruction of the resources involved when provision problems remain unsolved.

Obviously, I do not know if these appropriators reached optimal solutions to their problems. I strongly doubt it. They solved their problems the way that most individuals solve difficult and complex problems: as well as they were able, given the problems involved, the information they had, the tools they had to work with, the costs of various known options, and the resources at hand. I see my task as one of learning about the structures of the problems they faced and why the rules they adopted seem to work.

This means that I first try to understand something about the structure of the resource itself – its size, clarity of boundary, and internal structure. Then I try to discover the flow patterns involved in the resource units: How much predictability is involved over time, across space, and in quantity? Given the economic circumstances of the appropriators, how reliant are they on the resource, and what are the risks involved in various potential types of allocation schemes? Lastly, I try to ascertain key attributes of the individuals: How many are involved? What are their time horizons likely to be? Are they involved in multiple activities together? Are their interests roughly similar or heterogeneous? Have they established prior norms of behavior that can be drawn on (or pose a disadvantage) in trying to solve these problems? Then I examine the rules that they have devised and try to understand how they work by searching for the design principles that are involved and how these affect the incentives of participants. Given that the appropriators in these cases have engaged in mutual monitoring and generally have kept their commitments to follow their rules to a substantial degree, I try to understand how they have been able to do this.

In Chapter 4, I use this framework again to identify the structure of the situation that existed before a group of appropriators attempted to change their rules to solve several interrelated provision and appropriation problems. Then I examine the process of devising new institutions, in order to address the question of the supply of institutions. The "failure" cases in Chapter 5 are characterized by extreme rent dissipation, unresolved disagreements leading to physical violence, or resource deterioration. The same framework is used to identify the variables that account for that lack of success in solving appropriation and provision problems. I again assume that the individuals involved tried to do as well as they could, given the constraints of the situation. Thus, the problem is to identify what those constraints were, using the same framework for analysis.

In the concluding portions of this study, I discuss how the findings derived from an analysis of these cases can be used to advance theoretical understanding of a theory of self-organized collective action to complement the existing theories of externally organized collective action: the theory of the firm and the theory of the state.