

DESIGN PRINCIPLES FOR LOCAL AND GLOBAL COMMONS

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DESIGN PRINCIPLES FOR LOCAL AND GLOBAL COMMONS

Debates on institutional responses to global political and economic issues are dominated by the time-worn mind-sets of The State and The Market. On the one side, economists (and other analysts) sing the praises of market processes and advocate the definition of individual property rights as the standard solution to most problems of resource use. On the other side, analysts concerned with the lack of formalized rules or institutions in a particular issue area advocate adoption of a single global standard of behavior, which is usually conceptualized as the consequence of a new international treaty or convention. Although the formal intergovernmental organizations (IGOs) typically associated with international regimes fall far short of a global state, the supposed benefits of centralized management of global problems remains an important theme in many analyses of international cooperation.

Clearly, markets and formal organizational hierarchies (states or IGOs) are appropriate solutions for many circumstances. However, markets and hierarchies do not, by any means, exhaust the range of possibilities. Evaluation of alternatives to state and market has been the focus of the Institutional Analysis and Development (IAD) framework that has evolved out of several decades of work by colleagues associated with the Workshop in Political Theory and Policy Analysis (Kiser and Ostrom, 1982; E. Ostrom, 1986; Oakerson, 1986; V. Ostrom, Feeny, and Picht, 1988; V. Ostrom, 1991a, 1991b). In this paper, we use the framework of institutional analysis to help suggest ways of organizing and extending work on international cooperation.

In particular, we will draw on research on institutional arrangements in the management of common-pool resources (CPRs), usually in fairly small-scale settings.¹ A major focus of this work has been on micro-level, self-organizing and self-enforcing capabilities. Another focus of this work concerns the ways in which macro-political orders enhance or detract from the capabilities of those

directly involved in problem solving to create new institutions or reform prior institutions in order to cope more effectively with their own problems.

We argue that the conclusions of research on small-scale settings are relevant to the analysis of international cooperation for three fundamental reasons. First, the substantive nature of many local and global problems is similar. Second, despite vast differences in the scale involved in local and global commons, the underlying logical configuration of the CPR situation at these levels is fundamentally similar. Thus, the theoretical principles underlying successful cooperation at both levels are also similar. Third, any global regime that undermines the requisites for successful cooperation at the local level is unlikely to be sustainable in the long run.

After briefly reviewing the theoretical underpinnings and the major conclusions of this research program, we present an extended discussion of the application of these conclusions to issues of cooperation in the global political arena. We pay particular attention to the complications that arise from the diversity of the collective action organizations involved in global politics, as well as the ways in which this diversity can be used to enhance the robustness of global regimes. We conclude with a brief discussion of the types of game theoretic models that would be most useful for evaluating alternative institutional arrangements.

An Overview of the Institutional Analysis and Development Framework

The IAD framework helps identify the broad components and relationships among those components that are considered important for work when doing institutional analysis. To undertake analysis of a problem requires that the analyst draw on or develop theories that spell out more fully the specific variables involved in an analysis and the nature of the mechanisms that relate variables to one another. For well specified problems, the analyst may be able to develop formal models that generate quite specific predictions within the range of the model's applicability.

To engage in an institutional analysis, one first has to understand the structure of incentives facing actors in a situation, what choices are most likely to be made, and how these choices tend to produce particular patterns of outcomes. In other words, the first question is: What type of situation is this? To do this, one identifies a focal, conceptual unit, called an *action arena*, that is utilized to identify the structure of a problem and thus explain relevant behavior and outcomes. Action arenas include an *action situation* and the *types of actors* in that situation. An action situation is composed of participants holding diverse positions who make decisions from among the alternatives choices made available to them in light of the information they possess about the structure of the situation, the way their actions link to outcomes, and the benefits and costs they will receive. To make a theoretical prediction about the type of choices that various types of actors will make in a situation, one needs to know: (1) the resources that an actor brings to a situation; (2) the valuation that actors assign to states of the world and to actions; (3) the way actors acquire, process, retain, and use knowledge contingencies and information; and (4) the processes actors use for selecting particular courses of action.

Formal, game-theoretical models can be constructed to analyze the expected behavior of participants in highly structured situations. Many situations can be analyzed using these components including competitive markets, principal-agent relationships, legislative and committee decisions, the harvesting of resource units from common-pool resources, and the temptation to steal resource units from a common-pool resource. For highly simplified and stylized versions of these "universal" situations, it is even possible to establish the configuration of institutional rules that yield optimal results (Hurwicz, 1973). When the parameters of the models capture most of the important parameters involved in field settings, these models can be used to explain the types of outcomes obtained in the field and the likely response of individuals to changes in the incentives that the individuals face (see, for example, Plott and Meyer, 1975; Shepsle, 1979a, 1979b, 1989). Applying

models to the analysis of field settings whose structure differs in crucial aspects from the models results in mis-specified analysis, just as it does when a physical model is inappropriately applied.

To ascertain whether the models used to analyze policy relevant situations are appropriate, analysts must dig deeper than the initial givens of a model into the underlying structure of a situation that generates these givens. Here the focus of an IAD approach is on three broad classes of underlying factors: (1) relevant aspects of the physical, biological, and technological world; (2) relevant aspects of the broad cultural understanding and valuation of that world; and (3) the nested configurations of rules that affect the strategies that actors may, must not, or must take in the situation of interest. The key problem in designing effective institutions to control adverse effects on the environment is matching the specific set of rules that are to be used with the attributes and dynamics of the physical, biological, and technological world of relevance in a particular cultural milieu. In order to simplify our analysis, we will not address the potentially important role of cultural values on international cooperation for our initial analysis and focus first on the problem of matching rule configurations to complex physical worlds.

Matching Rules to Physical Worlds

The World of Private Goods

When individuals engage in transactions related to private goods, matching rules to physical worlds is relatively simple. Goods are considered to be "private goods" when:

- all aspects of the goods and services that individuals produce, distribute, buy, and sell can be excluded from actors who would like to use them (or, alternatively, others can avoid having externalities of a process dumped on them), and
- when any good consumed by one individual is unavailable for consumption by others, goods are considered to be "private goods" (E. Ostrom and V. Ostrom, 1977).

Rule configurations that generate an open competitive market are optimally efficient when used in relation to private goods (De Alessi, 1988). Unfortunately, only a limited number of the goods and services used by individuals possess the attributes of private goods. As soon as the goods involved do

not have these nice characteristics, it can be shown that various aspects of "market failure" occur and different types of institutions other than those of an open, competitive market may be needed.

The World of Common-Pool Resources

Common-pool resources (CPRs) possess only one of the characteristics of private goods. CPRs are defined to be natural or man-made resources in which (a) exclusion is nontrivial (but not necessarily impossible) and (b) yield is subtractable (E. Ostrom, Gardner, and Walker, 1991). CPRs share the attribute of nonexclusion with another broad class of problems that are referred to as public goods (E. Ostrom and V. Ostrom, 1977). The second attribute of CPRs that is shared with private goods but not with public goods is the subtractability of the yield (Samuelson, 1954). Another term used to describe this attribute is rivalness of consumption.

Let us first illustrate this attribute with examples drawn from research on groundwater basins, irrigation systems, fisheries, forests, grazing lands, computer systems, airport facilities, bridges, and other natural or manmade resources that generate a yield. All of these are resources that make available a flow of resource units over time. Examples of resource and resource units include: (1) a groundwater basin and the quantity of water pumped, (2) a fishing grounds and tons of fish harvested, and (3) a computer facility and processing time. The water withdrawn by a groundwater pumper is not available to anyone else. Nor are the fish caught by one boat or the CPUs used by one faculty member. The facilities or resources producing these units are, however, jointly used by multiple individuals.

When a few users first use renewable CPRs, what one person uses does not appear to subtract from what is available. Initially, the abundance of units relative to demand masks the subtractability. In some resources, such as fisheries, initial withdrawals may actually increase the amount jointly available. Fish compete for food resources, and harvesting some fish allows more fish to survive. If there are no rules in place to limit the use of a CPR, and if the resource unit that can be withdrawn is

valuable, then the structure of the situation leads users to invest more and more in harvesting activities. After a threshold has been reached, each individual's investment and harvesting activities adversely affects everyone else using the same resource.

Without rules to allocate resource units, users competing with one another for ever scarcer units may engage in destructive races against one another and their actions may destroy the very resource that is generating valuable yield for them. Garrett Hardin captured a key aspect of the problem of an open access CPR in his now classic use of the term, "Tragedy of the Commons."² Aristotle recognized a similar dilemma when he wrote: For that which is common to the greatest number has the least care bestowed upon it (*Politics*, Book II, Sec. 3). What Hardin did not capture was the capacity of the individuals involved in such tragedies to have sufficient insight into the problems that they faced to restructure their own rules and change the incentives they faced.

Where a resource produces a single, valuable resource-unit with a high level of predictability known to all participants (or, where storage facilities, such as dams, enhance predictability), it is possible to devise marketable rights or other simple, allocation rules that enable individuals to make efficient long-term use of the resource (Hurwicz, 1973; Clark, 1980). Blomquist (1992) demonstrates the enhanced efficiency achieved in groundwater systems when marketable rights to the flow are perfected. Fishery economists, drawing on the influential work of H. Scott Gordon (1954) and Milner Schaefer (1957), have developed important conceptual models of a predictable single species fishery where excessive harvesting is efficiently curbed by devising a transferable quota system (Scott, 1979, 1982). The same institution, however, is not at all efficient nor effective when applied to multi-species fisheries with complex interdependencies (Wilson, 1982; Townsend, 1986; Townsend and Wilson, 1987). Devising an efficient, effective, and equitable transferable quota system for a multi-species fishery is problematic (see Copes, 1986; Schlager, 1990). Many global CPR problems also

involve complex interactions among many interrelated processes and are unlikely to be solved with extremely simple institutional arrangements (see McGinnis and Ostrom, 1992).

Prior Research on Robust CPR Institutions

Prior research has included an intensive analysis of field settings where: (1) resource users have devised, monitored, and followed their own rules to control the use of a CPR, and (2) the resource systems, and as well as the institutions, have survived for long periods of time. The robust CPR institutions originally included grazing and forest CPR institutions in Switzerland and Japan and irrigation systems in Spain and the Philippine Islands (see E. Ostrom, 1990). Since then, many more cases of robust CPR institutions have been studied particularly related to irrigation and fishing systems (see E. Ostrom, 1992; Schlager, 1990; Tang, 1992).

In CPR institutions that have survived for long periods of time, operational rules-in-use have not necessarily remained fixed since they were first initiated. All of these environmental settings are complex and variable over time. In such settings, it would be difficult to get "the operational rules right" on the first try, or even after several tries. These institutions are "robust" or in "institutional equilibrium" in the sense defined by Shepsle. Shepsle (1989b: 143) regards "an institution as 'essentially' in equilibrium if changes transpired according to an *ex ante* plan (and hence part of the original institution) for institutional change." In these cases, the participants designed basic operational rules, created organizations to undertake the operational management of their CPRs, and modified the rules-in-use over time in light of past experience according to their own collective choice and constitutional rules.

In earlier work, we have developed two types of explanations. The first type of explanation has focused on why some institutions are robust in the Shepsle sense and others are not. The second type of explanation has focused on the factors most likely to affect institutional choice processes themselves (E. Ostrom, 1990: Chapter 6). The first focuses on the product of institutional choice processes and

asks why some survive for very long periods in delicately balanced situations and others do not. The second type of explanation focuses on the factors that affect the benefit-cost calculations of those who design institutions, so that we may better understand processes in which new rules are selected. In the present paper, we focus on the applicability of the first type of explanation for international regimes related to global change. In other words, what lessons can be drawn from research on robust CPR institutions that help us understand the conditions under which international institutions will support robust regimes?

In explaining why some CPR institutions are robust and others are fragile or fail entirely, we found that we could not develop a coherent explanation that focused on the *detail* of the specific rules used by robust CPR institutions. While the particular rules that are used within each setting cannot be the basis of an explanation for the institutional robustness and sustainability across these CPRs, part of the explanation is based on the fact that the particular rules differ. By differing, the particular rules take into account specific attributes of the related physical systems, cultural views of the world, and the economic and political relationships that exist in the setting. Without different rules, users could not take advantage of the positive features of a local CPR or avoid potential pitfalls that could occur in one setting but not others. *Given the diversity of the settings, one should not expect to be able to discover a single best formulation or set of optimal mechanisms.*

Instead of similar specific rules, there are similar design principles that characterize all of the robust CPR institutions. By "design principle" is meant an essential element or condition that helps to account for the success of these institutions in sustaining the CPRs and gaining the compliance of generation after generation of participants to the rules-in-use.³ Focusing on underlying principles rather than specific mechanisms may enable us to learn lessons from a wide diversity of small field settings that have relevance to the design of robust international regimes.⁴ The design principles of robust CPR institutions were identified as:

1. Clearly Defined Boundaries. Individuals or households who have rights to withdraw resource units from the CPR must be clearly defined, as must the boundaries of the CPR itself.

2. Congruence between Appropriation and Provision Rules and Congruence Between Provision Rules and Local Conditions. Appropriation rules restricting time, place, technology, and/or quantity of resource units are related to local conditions and to provision rules requiring labor, materials, and/or money.

3. Collective-Choice Arrangements. Most individuals affected by operational rules can participate in modifying operational rules.

4. Monitoring. Monitors, who actively audit CPR conditions and participant behavior, are accountable to the participants or are the participants.

5. Graduated Sanctions. Participants who violate operational rules are likely to assessed graduated sanctions (depending on the seriousness and context of the offense) from other participants, by officials accountable to these participants, or by both.

6. Conflict Resolution Mechanisms. Participants and their officials have rapid access to low-cost, local arenas to resolve conflict among participants or between participants and officials.

7. Minimal Recognition of Rights to Organize. The rights of participants to devise their own institutions are not challenged by external governmental authorities.

8. Nested Enterprises. Appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities are organized in multiple layers of nested enterprises.

The Global Relevance of Research on Local CPR Regimes

There are several reasons why we think the lessons learned from past research on micro CPRs has substantial applicability to the problem of dealing with patterns of international cooperation and conflict. These include:

1. The analytical structure of some global problems shares similar features with the analytical structure of many local CPRs.
2. Starting with theories and models devised for the analysis of local CPRs may speed the work in developing theories and models at a global level.
3. Many global problems (e.g., deforestation) are themselves the result of inadequate solutions at a micro-level of a complementary and interactive commons problem.

To the extent that global commons dilemmas share analytical attributes with smaller scale CPRs, the theoretical and empirical lessons learned from studying micro-level phenomena may "scale-up" so that direct lessons may be learned. Analyzing complex patterns of interaction in the simplest possible example of the structure (the biologist's strategy), may enable the analyst to understand the way things work in the simplest exemplar without being overwhelmed by the sheer complexity of the problem. To the extent that work at a micro-level does not easily scale up, it still may be the case that key variables are identified in micro-level theories and models. Starting with the work at this level may save considerable time as contrasted to an effort to move to the global level directly. Even though it is impossible to completely decompose global problems into entirely discrete subproblems, working upwards may enable solutions to be reached faster than starting from the global and working downwards—at least for some subset of problems (see Ashby, 1960; Polanyi, 1951).

As an example of a global problem rooted in inadequate local arrangements consider the contribution of deforestation to global climatic change (Cruz, 1991). Deforestation may be the result of conversion from lower valued to higher valued uses. It may also be the result of either (1) ill-defined property rights where the transaction costs of gaining clear property rights (whether strictly private or communal) are very high, or (2) the creation of a concession economy as the foundation for resource mobilization by national-government officials (for their government as well as for themselves). Problems like deforestation will deteriorate still further until more effective institutional arrangements can be devised at the local level. Given the varieties of physical environments that exist within even one country, no single set of rules related to the use of forests will create appropriate incentive systems for all individuals whose decisions affect the regeneration of forests over time.

Another major point of similarity is the shared concern for finding means to cooperate despite the absence (or disinterest) of a higher level of political authority. Research on international regimes has emphasized the ability of governments to cooperate in an environment of "anarchy," defined as the

absence of any central authority at the global level. Political order at the international level is primarily self-enforcing, in the sense that governments frequently resort to military force to achieve their goals or to restore the "peace." Despite its obvious shortcomings on normative grounds, war remains the ultimate means of conflict resolution that may never be dispensed with until a complex, multi-tiered world government is established in some remote future time.

Since many of the micro-settings where individuals have jointly devised their own institutions have existed far from the purview of national, regional or local government officials, the design of these institutions and their enforcement has not always depended on the presence of a "State". Many of the self-organized institutions devised in these micro-settings are not dependent upon enforcement of their rules by external officials. Further, since many of these micro-institutions are neither a market nor a state, we may gain insight to alternative international institutions from studying these micro institutions.

On the other hand, we are cautious about casual analogies. We fully recognize that there are substantial differences in the range of actors involved in many global problems. In many of the micro-studies, the actors involved are individuals whose own livelihood depends strongly on solutions to use a resource system more efficiently over time. In many local commons around the world, individuals do devise for themselves rather ingenious institutional arrangements that have enabled them to make productive use of fragile resource systems over long periods of time. Even then, there are many "tragedies of the commons" in these situations where individuals as principals interact directly with one another.

Once we move to the problem of the global commons, in addition to the millions of individuals who make choices, we add many corporate actors who are designated as the agents for complex publics and their behavior is far more complex. Yet, many corporations and national governments can reasonably be expected to exist for long periods of time, providing them with incentives to

establish predictable rules of behavior that reduce future levels of uncertainty (Keohane, 1984). One issue that we emphasize below is the extent to which the nature of these collective action organizations affects the patterns of monitoring and sanctioning that can realistically be expected to occur in any global regime.

In the next sections we begin the process of speculating about how the CPR design principles should be transformed to be relevant for regimes created at the international level to cope with global commons issues such as climate change due to increased greenhouse gases present in the stratosphere.

Boundaries and Actors: A Preliminary Typology

The first design principle for robust CPR institutions focused on a clear definition of who had rights to engage in appropriation activities and of the physical boundaries of the resource system itself. This was thought of as the first step in organizing for collective action. So long as the boundaries of the resource and/or the individuals who can use the resource remain uncertain, no one knows what they are managing or for whom. Without defining the boundaries of the CPR and closing it to "outsiders," participants face the risk that any benefits they produce by their efforts will be reaped by others who do not contribute to these efforts. Thus, for any participants to have a minimal interest in coordinating patterns of appropriation and provision, some set of participants have to be able to exclude others from access and appropriation rights. If there are substantial numbers of potential users and the demand for the resource units are high, the destructive potential of all users freely withdrawing from a CPR could change the perception of users regarding the likely continuance of a flow of resource units in the future. If participants fear for the future sustainability of the resource, the closer the situation is to that of a one-shot dilemma where the dominant strategy of all participants is to overuse the resource. (This is the logic behind Aristotle's assertion quoted above.)

At the international level, the corporate nature of the actors is particularly relevant to predictions about activities and outcomes. A diverse array of organizational actors participate in the global arena,

including national and sub-national governments, international governmental organizations (IGOs), domestic economic corporations and multi-national corporations (MNCs), and domestic nongovernmental organizations (NGOs) and international nongovernmental organizations (INGOs). We propose a typology of actor types based on the three-fold characterization of political, economic, and epistemic contingencies that constitute patterns of order in human societies (V. Ostrom, 1991b). The point of this typology is not to locate any particular organization in some pigeonhole, but rather to identify the combinations of interests and capabilities that most commonly impinge on international cooperation.

Groups of individuals form different types of collective action organizations to pursue diverse goals. Individual agents in different organizations are then authorized to undertake specific actions. In addition to their personal goals, agents of economic corporations are driven by pursuit of profit, political agents by a desire to remain in office and to achieve certain policy goals, and agents of nongovernmental organizations strive to attain the purposes that inspired formation of that type of organization. Some INGOs, such as Amnesty International, are widely regarded as impartial sources of information relevant to various areas of international relations. Others, such as Greenpeace, become direct action groups that play a distinctive, confrontational role in political processes.

Even though any particular association may be simultaneously engaged in economic production as well as rule-making and knowledge-generating activities, different types of associations tend to emphasize one of the other type of activity. In Figure 1 we use these characteristic goals and/or arenas of activity to differentiate among the type of actors most relevant to analyses of international cooperation. (We differentiate among governments grounded in fundamentally different forms of political order below.)

It is important to treat actors in the epistemic category as having distinctive interests and capabilities, rather than relegating them to a residual "other" category left after political and economic

actors have been identified. For example, Peter Haas (1989) emphasizes the role played by technical experts in establishing the political pre-conditions for effective control of pollution in the Mediterranean Sea. He argues that regimes are most effective when based on consensus among a technically informed "epistemic community" about the nature of the problem to be solved and the merits of alternative solutions. In other words, technical experts share a "common understanding" that can provide a basis for political cooperation. The phrase "epistemic community" frequently appears in analyses of the prospects for increased international cooperation on environmental issues (P. Haas, 1992). Technical experts may play a large role in monitoring governmental or corporate behavior, by providing an impartial source of information upon which sanctions could be based. Even if the information provided by "public interest" groups is seen as biased, competing information provided by more blatantly self-interested corporate groups can also be taken into account. It is important to realize that no one group, nor any type of collective actor, has a monopoly on legitimate participation in these inherently political processes.

For some purposes a particularly important distinction is the scale of the activities of collective action organizations. We have in mind especially the standard distinction between "domestic" and "international" organizations (see Figure 1). The prominence given "sovereign states" in the international relations literature and in practice requires this distinction be used for some analytical purposes, even though many important actors and networks transcend national boundaries. In general, agents of collective action organizations formed by members of the same political community may tend to pursue different goals than agents of organizations drawn from multiple communities. For example, agents of national governments pursue different goals and fulfill different roles than do the "international civil servants" that carry out the activities of IGOs. Similarly, domestic corporations may have interests that are systematically different from multinational corporations, especially regarding such matters as restrictions on foreign trade or currency exchanges. Although domestic and

international nongovernmental organizations tend to resemble each other more closely, in some circumstances the distinction between NGOs and INGOs may be important.

Some organizations are difficult to locate in any one of these categories. Should cartels of drug dealers be treated as multinational corporations? Or should drug cartels and terrorist groups be included in the same NGO (or INGO) category as religious and scientific organizations? Do some national governments engaged in the international arms trade tend to take on the interests and characteristics of purely economic agents? Despite some remaining ambiguities, these basic distinctions among governments, IGOs, domestic corporations, MNCs, and domestic and international nongovernmental organizations remain valid for many analytical purposes.

In applying the first design principle at the international level, then, one has to focus on a specification of the full array of corporate actors who will participate in the governance, management, and use of international resources. If the resource in question is genuinely global, such as the stratosphere, then the boundaries of the resource itself are easily to define. This is not the case in regard to many international regimes where the resource of interest crosses national boundaries (such as the Mediterranean Sea) but where substantial question exists concerning how to define the relevant physical borders. Using toxic chemicals in industrial plants in Basel, Switzerland, can potentially affect water quality in the Mediterranean if the toxic chemicals are allowed to enter the Rhine. Thus, devising an appropriate set of physical boundaries is frequently a challenging part of devising international regimes.

Congruence among Rules and with Local Conditions

The second design principle involves two parts. The first stresses that rules affecting the distribution of costs and duties in robust CPRs are closely related to the distribution of benefits and rights. The second part stresses that the rules are tailored to fit particular local circumstances.

The first part will be particularly difficult to achieve in the design of regimes where the interests of the developed and developing countries are quite diverse. In regard to global climate change, for example, the question of how to allocate the *costs* of reducing emissions of greenhouse gases will be extremely difficult to resolve. There is no single criteria of fair allocation that both North and South will automatically agree is fair for this problem. If cutbacks are assigned proportionate to historical use—a rule frequently used in robust CPR—developing countries will not be able to achieve the level of well-being associated with levels of per capita energy use. If cutbacks are assigned so that per capita energy use is equalized, the *cost* of the cutback is most severely felt in the developed countries.

Matching rules to physical conditions in regard to international resource problems is also a greater challenge than is present in smaller CPR settings. Many local factors affect how a change in one variable impacts on others. Thus, devising *uniform* rules to cover the globe may have exactly the opposite effect than intended. Following such a rule in some locations may produce harmful rather than beneficial effects.

For example, rules that require all upstream nations to reduce the siltload of international rivers radically presume that any human intervention in a watershed that increase the siltload carried downstream produces a harm. Rawlins (1991) argues quite convincingly that the movement of silt from one location to another may enhance overall agricultural productivity. Whether the movement of silt improves or degrades agricultural productivity depends on many attributes (temperature, soil density and depth, costs of transportation) that affect the potential of higher versus lower sites. Thus, whether moving silt is land degradation or land improvement depends upon many other factors that are present in a unique configuration in any particular watershed.

Similarly, it appears that the effect of some chemicals on tropospheric and stratospheric ozone depend on the amount of other chemicals present in a micro- or meso-environment. Interventions based on incomplete understandings of these complex processes can inappropriately attempt to regulate

all environments as if they were similar in structure. Such interventions can be ineffective (and, thus inefficient because of their cost) or even counterproductive.

A recent report released by the National Research Council, for example, criticizes the U.S. Environmental Protection Agency (EPA) for focusing too strongly on one pollutant (Commission on Geosciences, Environment, and Resources, 1991). Tropospheric ozone (smog) is generated when two classes of chemicals react in sunlight: (1) volatile organic chemicals (VOCs) and (2) either nitric oxide or nitrogen dioxide (NO_x) (see *Science*, January 3, 1992, p. 26). In some regions of the U.S., a high ratio of VOCs to NO_x exists. "In such regions, the report concludes, it may be better to concentrate on the less abundant pollutant to prevent the formation of ozone" (*ibid*).

To make the situation even more difficult, one source of VOCs has not been monitored until recently.⁵ Trees and most plants produce biogenic VOCs (such as isoprene). Heavily wooded areas would thus generate a high ratio of unmeasured VOCs to NO_x even if most man-made VOCs were eliminated. In such areas, applying a uniform rule based on a model that smog can be controlled by reducing VOCs would be an ineffective strategy. Given these recent findings, it may now be possible to understand why twenty years of heavy regulation has yielded little or no progress in the reduction of tropospheric ozone. Regulations have been based on a over-simplified, universal model of single source smog production. While all physical processes follow universal laws, the particular processes to be controlled in any specific location involve a complex, frequently non-linear, combination of the specific values of multiple variables.

Results from recent research on the effect of diverse anthropogenic aerosols on global warming reveal spatially and temporally nonuniform patterns. Research reported on by R. J. Charlson and colleagues from many of the major research labs related to Atmospheric Sciences in the January 24, 1992 issue of *Science* shows a surprising effect concerning the role of tropospheric aerosols in producing a cooling effect. Charlson, et al. (1992: 429) conclude that "anthropogenic sulfate produces

a mean radiative forcing of the [northern hemisphere] climate that is comparable in magnitude but opposite in sign to the anthropogenic perturbation in forcing by greenhouse gases." Further, they stress both the spatially nonuniform distribution of and large uncertainties about the magnitude of the presence of tropospheric aerosols. Trying to understand how these complex chemicals interact in different micro and meso climate systems is essential if future regulations aimed to prevent global warming are to be effective. Charlson and his coauthors strongly urge a research program that combines data collection and modelling at smaller as well as global scales.

Another new study demonstrating nonuniform temporal reactions has been conducted by Thomas R. Karl of the National Climatic Data Center in Asheville, North Carolina (and reported on in the February issue of *Scientific American*, see Beardsley, 1992). Previous assessments of global warming have presumed that daytime and nighttime temperatures would increase equally as the level of greenhouse gases increases. Karl's study shows that temperatures in the Northern Hemisphere have increased primarily at night and recorded as daily minimum temperatures. "Daily maxima, on the other hand—generally recorded during daylight hours—have hardly increased at all in the U.S. and China and only a little in the Soviet Union" (Beardsley, 1992: 21). The significance of Karl's and Charlson's work is currently under debate. But if sulfate aerosols do tend to counteract warming processes—even those during the day—the implications for regulations that focus on a reduction of pollution from fossil fuels might have counterproductive consequences. As Beardsley concludes (1992: 24):

If sulfate aerosol is indeed ameliorating daytime greenhouse warming, the implications for public policy could be perplexing. Nighttime warming would still be ecologically disruptive and would still melt glaciers. And the provisions of the U.S. Clean Air Act and steps by other countries to reduce pollution from fossil fuels may have an unintended effect. If the sulfate theory is right . . . the decrease in sulfate emissions might hasten global warming.

While much more needs to be learned about the factors affecting global warming, it does appear that many of the elements that enter into processes that change global weather patterns are not

distributed in a spatially uniform manner. Since the effect of reducing the levels of one chemical depend upon the mixture of other chemicals present in the atmosphere, uniform rules are likely to produce some counterproductive results as well as some ameliorative results. Successful efforts to control environmental problems may end up being those that are best matched to micro- or meso-level environments rather than trying to devise rules at a global level.

Collective Choice Arrangements in Self-Organized and Nested Regimes

Design Principle 3 points out that robust CPR institutions are ones where participants had been able to design their own rules, and Design Principle 7 focuses on the recognition of this right to organize. One consequence of the operation of these principles is that rules better matched local circumstances (Design Principle 2). In this section we elaborate upon some of the implications of Design Principles 2, 3, and 7 in relation to Design Principle 8, which notes that, for large-scale CPRs, appropriation, provision, monitoring, enforcement, conflict resolution, and governance were organized in multiple levels of nested systems. We presume that *all* international regimes must be nested regimes. Thus, we focus on the problems of achieving robust collective choice arrangements in nested regimes.

When extended to multi-level regimes, Design Principle 2 implies that institutional arrangements must be closely related to the physical realities of the environmental situation, at all levels of aggregation. Thus, if the boundaries of a river basin do not correspond to the official boundaries among sovereign states, groups within all affected states must be included (whether or not all national governments are directly represented). An example of relatively successful cooperation among a large group of heterogenous governments is the control of pollution in the Mediterranean Sea (P. Haas, 1989, 1990). Furthermore, intergovernmental negotiations should not be considered the only, nor even the best, forum for the global cooperation. Sometimes international agreements play an important role, but they rarely (if ever) tell the whole story. Although it might seem obvious that a global

problem necessarily requires a solution that is similarly global in scope, no global regime can remain robust if it neglects to take account of local circumstances or the conflicting interests of smaller-scale collective action organizations.

Considerable caution has to be exercised in moving from micro to macro levels, since a change in scale frequently changes the structure of situations dramatically. On the other hand, lessons acquired from studying micro-institutions cannot be dismissed as inappropriate for applications to macro-institutions simply on the basis of a distinction between homogeneous local groups and the heterogeneous actors involved in the global system. Many successful CPR regimes are complex structures and include individuals from diverse cultural groups. Homogeneity may make it easier for groups to attain the degree of common understanding essential to the operation of robust CPR regimes, but none of the design principles listed above requires actor homogeneity. Even very diverse actors can arrive at a degree of common understanding sufficient to enable them to effectively deal with their common problems.

Sustainable global regimes must make sense at all levels of aggregation: local, regional, national, transnational, and global. Institutional arrangements at these multiple levels must be nested in such a way that the institutions at each level are robust to the type of challenges that are likely to arise at that level. For if the local manifestations of global regimes fail to satisfy the design principles identified above, then that regime is subject to fragility and eventual dissolution.

This nesting cannot be expected to happen automatically. Quite the contrary is the case, since successful management of resources by some local group often imposes negative externalities on other groups. In such circumstances, some means must be found by which representatives of affected groups can come together to establish mutually beneficial institutional arrangements. Despite the current emphasis on state-to-state negotiations, this type of interaction should be expected to take place at all levels of aggregation.

The design of nested regimes necessarily exacerbates standard problems of principal-agent relations, namely, the dilemmas associated with efforts to insure that an agent selected to act in the name of a principal will pursue the interests of the principal rather than acting solely out of self-interest (see Moe, 1984, 1989). Nested regimes involve complex structures of inter-related agents and principals, in which most actors serve both as agents of some larger principal and as principals delegating authority to some set of agents. Ideally, arrangements at local and intermediate levels are incentive-compatible, in the sense that the interests of agents are somehow made to coincide with the interests of the principal.

In addition to the standard problems of collective action, international negotiations over global commons issues are greatly complicated by their inherent uncertainty. Governments and other actors may bear significant costs if a given global problem is not resolved, but these costs remain in the future, whereas the policy changes being proposed may impose very real short-term costs on particular governments or corporations.

This is an example of a classic dilemma of collective action: a large group of potential beneficiaries facing diffuse and uncertain gains is much harder to organize for collective action than clearly defined groups who are being asked to suffer easily understandable costs. Existing literatures assert that one of two types of leadership is crucial to resolve this dilemma. First, small privileged groups may find it in their interests to directly provide the public good (Olson, 1965). Second, some political (or other) entrepreneurs may take the lead in educating members of the relevant groups as to the nature of the common problem they face. In the international regime literature the first type of leadership is typically attributed to hegemonic powers (Keohane, 1980, 1984) and the second to technical experts in the form of epistemic communities (P. Haas, 1989, 1992). The record of robust CPR regimes reviewed above clearly demonstrates the ability of individuals to solve difficult dilemmas

of collective action even in the absence of a dominant leader, but some form of common understanding is critically important.

Any political bargain on a global scale should be grounded on some clear fundamental principles, both normative and practical (see Cleveland, 1990/91; Dorfman, 1991). The principles cannot be imposed, but must instead emerge from a process of contestation in which a wide range of feasible alternatives are given careful consideration.

Perhaps the most important nesting principle is that the interests of all relevant groups must be incorporated in the ultimate agreement, or else the regimes's sustainability will be undermined by those groups whose interests are excluded. It is not enough to impose an arrangement by majority vote (of, for example, the UN General Assembly), for those groups whose interests are not represented will dismiss the result as unfair or illegitimate. Instead, we should expect complex linkages between different issues, as occurred in negotiations over the Law of the Sea Treaty (Sebenius, 1984, 1991). Negotiators should also be attentive to possibilities for side-payments of various sorts, in order to complete a mutually advantageous package deal.

For example, a diverse array of interests will be pursued by collective action organizations seeking to affect the shape of any future global climate regime. The governments of advanced industrial democracies must respond to pressures from domestic environmental groups as well as the economic corporations that produce the vast array of consumer goods deemed essential to our modern society. Governments of developing countries must strike a balance between external inducements to minimize environmental degradation (especially deforestation and desertification) and domestic pressures for economic growth and development. Multinational and domestic corporations seek stable and predictable laws and regulations that will facilitate their continuing pursuit of profits. Private voluntary organizations will press the claims of scientists and environmentalists, no doubt too vigorously for the comfort of the leaders of established governments and corporations. Finally,

international civil servants will press for establishment of additional levels of bureaucracy at the international level as well as insuring access to more regularized sources of income. The task of reconciling such a wide diversity of interests is truly formidable.

Designers of global regime can draw important lessons from the designers of the U.S. Constitution, who concentrated on finding ways to balance power against power, to use contestation among individuals to provide a firmer foundation for achieving public order (see V. Ostrom, 1987). Rather than seeing the diversity of actors and interests as an impediment to agreement, it is important to put this diversity to use in order to increase the robustness of any resulting regime. For example, statistics provided by official government sources can play some role in helping to monitoring greenhouse emissions, but they cannot remain the sole source of information. If so, then government officials might have strong incentives to misreport levels in order to protect their own government from punishments, and they might also be subject to bribery by corporate officials eager to cover up their own excessive use of carbon fuels. Insuring regular alternative sources of information is essential. In the next section we turn to a more detailed examination of the principles underlying the monitoring and sanctioning of robust global regimes.

Monitoring and Sanctioning in International Regimes

The problem of gaining compliance to rules—no matter what their origin—is frequently assumed away by analysts positing all knowing and all powerful *external* authorities that enforce agreements. In many robust CPR institutions described in E. Ostrom (1990), no external authority had sufficient presence to play any role in the day-to-day enforcement of the rules-in-use. It has been surprising to find that monitoring and sanctioning are undertaken not by external authorities but by the participants themselves in the robust institutions. The initial sanctions used in these systems are also surprisingly low. Even though it is frequently presumed that participants will not spend the time and effort to

monitor and sanction each other's performance, substantial evidence exist from field settings as well as from the experimental lab (see E. Ostrom, Gardner, and Walker, 1992, forthcoming).

The costs of monitoring are kept relatively low in many of the long-enduring CPRs as a result of the rules-in-use. Institutional analysis that simply posits an external, zero-cost enforcer has not addressed the possibility that the rules devised by participants may themselves have a major effect on the costs, and therefore the efficiency, of monitoring by internal or external enforcers. Similarly, monitors who do a good job are rewarded and inadequate monitors are punished.

Further, since the users tend to continue monitoring the guards as well as each other, some redundancy is built into the monitoring and sanctioning system. A failure to deter rule breaking by one mechanism does not trigger a cascading process of rule infractions since other mechanisms are in place. Thus, the costs and benefits of monitoring a set of rules are not independent of the particular set of rules adopted. Nor are they uniform in all CPR settings. When participants design at least some of their own rules (Design Principle 3), they can learn from experience to craft enforceable rather than unenforceable rules. This means paying attention to the costs of monitoring and enforcing as well as the benefits that those who monitor and enforce the rules obtain.

Having earlier proposed a classification scheme based on the dominant objectives of organizations and their scope of activities, we would now like to focus on two of the dimensions that are closely related to the design principles 4 and 5 described above. That is, in this section we examine how the type of actors involved in monitoring and sanctioning may affect the types of incentives and likely outcomes produced. We realize that the type of actors involved in constitutional decisions affects who participates in a regime and which type of authority and scope rules are used, and we also are concerned about the types of dispute resolution that can be adopted depending on the types of actors. But a preliminary focus on monitoring and sanctioning activities seems warranted by their fundamental

importance for any effort to achieve meaningful and sustainable changes in the level of international cooperation.

We distinguish categories of regimes according to (1) what type of actor is primarily responsible for monitoring compliance with the rules of that regime and (2) what type of actors is sanctioned for rule violation. This latter type of actor is generally the same as the type of actors whose behavior is restricted, although this relationship is not necessarily the only option. For example, national governments could be sanctioned for the activities of domestic corporations that violate rules laid down in a given regime.

Since the extent to which an IGO can be considered to be a separate actor remains in doubt, we do not consider the possible existence of regimes in which IGOs are sanctioned. (Efforts by the Reagan administration to withhold payment of U.S. dues to some United Nations organizations can be interpreted as sanctions against some of their previous activities.) However, IGOs can fulfill important information gathering functions, including monitoring the behavior of governments, corporations, and other organizations (Jacobson, 1984). Also, for these purposes there seems little reason to distinguish between domestic corporations and MNCs, or between NGOs and INGOs. This leaves us with four types of actors engaged in monitoring activities (IGOs, governments, corporations, private groups) and three actor types subject to sanctions (governments, corporations, private groups or individuals).

Not all of the resulting 12 categories are relevant to the existing set of international regimes. Illustrative examples of relevant categories are given in Figure 2. These categories are rough, and many real world cases will fail to fall clearly within a single category, especially since many different types of groups may be engaged in monitoring activities. Nonetheless, we believe this categorization has some utility in preparing the way for a more precise analysis of international regimes. In Figure 2, numbers are assigned to each of the categories discussed below.

1. Government Monitored—Government Sanctioned

Realist theorists of international politics focus almost exclusively on situations in which governments play both roles, that is, regimes that fall within category 1. In his classic study of international order, Bull (1977: Chapter 3) argues that "sovereign states," which he interprets as individual members of "international society," are primarily responsible for performing all functions of rule making, monitoring, interpreting, legitimizing, and enforcement at the international level. For example, compliance with U.S.-Soviet arms control treaties has been monitored by each government's intelligence agencies (see Carnesale and Haass, 1987; Gaddis, 1987).

The international law of war also fits into this category. Many observers are reluctant to describe war as an orderly activity, yet war has long served as a prominent institution of "international society" (Bull, 1977), and certain restraints on the use of force are widely (but not universally) observed. The application of regime analysis to war or security rivalries remains controversial, but we take the position that any regime will include some mixture of cooperation and conflict, and thus that some regimes will be rather more conflictual than others.

Even relatively clear examples of the imposition of sanctions on national governments illustrate the extent to which international law falls short of the standards of domestic legal systems. Since Iraqi intervention in Kuwait was widely seen as a violation of international agreements against aggression, it was relatively easy to arrange global agreement on the imposition of economic sanctions on Iraq. Yet, this example reinforces concerns about the fairness of applying sanctions to collectivities rather than to individual actors raised in *The Federalist* (see V. Ostrom, 1987). After all, the individual policy makers responsible for Iraqi actions were able to circumvent the deleterious effects of economic sanctions, which fell hardest on the poor and powerless elements of Iraq's population. Although economic sanctions have been used several times in recent decades, the use of physical force to enforce UN resolutions remains very unusual. Despite President Bush's claims that

these events signal the birth of a new world order, it is more widely believed that the ability of the U.S. government to garner such widespread support for military enforcement must be attributed to special circumstances that are unlikely to be repeated.

2. IGO Monitored—Government Sanctioned

In category 2 an IGO is established to monitor governments' compliance with an international agreement. For example, the Nuclear Non-Proliferation Treaty established an international agency (the IAEA) intended to monitor possible violations (see Pilat, 1992). As for any other bureaucracy, care must be taken to somehow make it in the self-interest of individual bureaucrats to report accurately and reliably, and the data reported by IGOs cannot be honestly evaluated without some consideration of the purposes that willful misrepresentation might serve. However, the actions of most IGOs are generally seen as relatively impartial, perhaps because IGOs have too small a resource base to sustain extravagant graft or corruption, at least in comparison to many national governments.

3. Corporation Monitored—Government Sanctioned

Category 3 encompasses the standard set of international economic regimes. Although typically established by negotiations among national governments, economic corporations are the actors most directly involved in monitoring compliance with rules against imposing trade barriers or unfair trade practices. Corporations keep careful track of any advantage gained by their international competitors. Once violations are detected, corporations and economic interest groups typically press their own governments to seek redress of the violations through negotiations with the other government. For example, accusations of Japanese dumping of automobiles on the American market were resolved by a bilateral agreement on voluntary import restraints. Other types of policy changes include imposing penalties on corporations engaged in unfair trade practices (see Jackson, 1990). Thus, the policies of national governments lie at the center of economic regimes, even though the monitoring is usually handled by those corporations most directly affected by rule violations. This central location of

governments opens up several opportunities for rent-seeking and other predatory activities, especially by governments relying on concessions from MNCs as their primary source of revenue. (We discuss this problem below.)

4. Government Monitored—Corporation Sanctioned

Category 4 includes examples of agreements between a multinational corporation (MNC) and a less developed country (LDC) that serves as "host country," in the sense that some of the economic activities of that MNC occurs within that country's territory. LDC governments can use sanctioning mechanisms ranging from increased taxation to outright expropriation (or "nationalization") of MNC property. MNCs have access to national courts, but these are unlikely to impose real punishment on their own governments. MNCs, on the other hand, can frequently threaten moving their business activities elsewhere. Indeed, it is often asserted that, in most circumstances, MNCs have unfair bargaining advantages over their LDC hosts. A major unachieved goal of negotiations concerning establishment of a New International Economic Order was to establish some international regulation of the activities of MNCs.

5. IGO Monitored—Corporation Sanctioned

Instances of category 5 regimes, in which IGOs monitor compliance of economic corporations to international agreements, point the way towards establishment of a fundamentally new international legal framework. A potential example is the Law of the Sea Treaty, which calls for establishment of an international agency that would regulate mining activities on the deep seabed outside the 200-mile offshore exclusive economic zones also established in that treaty. The purpose of this International Seabed Authority is to insure that profits from these mining activities are distributed to all peoples of the world. Concern with the precedent set by this example of international control of a still-emerging area of economic activity led the Reagan administration to refuse to sign the LOS treaty. The extent

to which similar international agencies will be established to redistribute profits made in other areas considered to be the "common heritage of mankind" remains to be seen.

6. Private Monitored—Government Sanctioned

In category 6 regimes, NGOs monitor government activities that may be subject to sanctioning under emerging regimes, as in the area of the protection of individual human rights. Governments have long monitored the ways in which other governments treat ethnic or religious minorities of concern to them. More recently, private groups, such as Amnesty International and the various groups established in Eastern Europe after the signing of the Helsinki Accords, have achieved credibility as relatively impartial monitors of human rights violations. In this case, application of sanctions to a government is clearly appropriate, since it is the oppressive activities of the government itself, or by some of its agents, that is of concern. Thus, the link between the identity of the rule violator and the target of sanctioning is more direct than in economic regimes.

Scientists and environmental action groups are likely to emerge as the most credible monitors of future international environmental regimes. In many proposed schemes governments would bear the brunt of punishment for allowing domestic corporations to violate internationally established restrictions. For example, in the Ozone Convention national governments agreed to establish guidelines for certain emissions for all industrial activities within their borders. Each government is delegated to incorporate these into its own legal system. Then it remains up to the governments involved to decide how to allocate these limits to domestic corporations.⁶

7. Private Monitoring—Corporations Sanctioned

Innovative proposals to establish a market in pollution permits (e.g., Victor, 1991) might retain a major governmental influence in setting limits on these permits, but the underlying logic is fundamentally different. Since these permits would be purchased by corporations, the onus for exceeding limits would fall on individual corporations. That is, the overall emissions within a given

territory might exceed the limit that would have been set under some international convention, but as long as the corporations polluting that territory had obtained sufficient permits there would be no violations of that regime. A regime of that type would fall under a new category of private monitoring and sanctioning of corporations, marked by 7 in Figure 2.

8. Government Monitored—Private Sanctioned

In Category 8 regimes, private groups or individuals are subject to sanctions imposed by other governments. Proposals for establishment of a New International Information Order in which international news media would have been subject to explicit regulation by governmental authorities would point towards such a regime, since disgruntled governments would supposedly have been able to punish news organizations for unflattering news reports, but this regime was not established. Examples of category 8 regimes are extremely rare, with perhaps the best example being the war crimes trials after World War II, in which the victorious powers established tribunals to establish individual guilt for crimes considered unacceptable within the standard tenets of the laws of war. More recent examples include abduction of reputed terrorists to stand trial in the country in which their victims lived, or the practice of using U.S. courts to try deposed dictators for corruption (e.g., Marcos and Noriega). Complete realization of this type of regime awaits establishment of a new constitutional order at the global level.

Other Combinations

The remaining categories are less directly relevant to international regimes, at least as they are normally conceptualized. An example of the type of issue that would arise in a regime in which corporations monitor and sanction each other would be a typical cartel arrangement, which are often technically illegal. In other situations, corporations may monitor each other but receive sanctions from some external source, as in cases where one corporation sues another for patent infringement. Our understanding is that such disputes can usually be handled under the confines of existing "private

international law," which differs from "public international law" in dealing with the activities of groups and individuals rather than the activities of public authorities (usually in terms of national governments). Further development of the international legal system towards increased similarity with domestic legal systems might well prove a key step in transforming our current state-centered system into an entirely new form of world order, but for now we leave the remaining cells in Figure 2 blank.

Contestation and Conflict Resolution

Negotiations among national governments are an essential step in the original establishment of a global regime, but the continued participation of governments in the day-to-day operation of that regime may be more problematic. National governments play a relatively minor, mostly supportive role in many robust CPR regimes. Participants in these regimes frequently devise their own rules without having created formal, governmental jurisdictions for this purpose. So long as external governmental officials give at least minimal recognition to the legitimacy of such rules, participants may be able to enforce the rules themselves. Also, governmental officials are available to cope with the inevitable conflict that arises over the interpretation of rule-governed systems. But if external governmental officials presume that only they can make authoritative rules, then it is very difficult for local participants to sustain a rule-governed CPR over the long run. At any point when someone wishes to break their rules, they can go to the external government and get local rules overturned. Similar problems may attend any international regime in which disaffected actors can easily turn to governments for redress of their grievances.

Of course, governmental action will remain as a last resort for use in dire circumstances. But it is important that other arenas be set up in which contending parties can resolve their differences. Establishing institutional arrangements in which diverse types of collective actors can engage in open contestation and conflict resolution remains a difficult challenge, particularly when these actors include national governments jealously guarding their sovereignty.

Another important consideration is the nature of the political order within which any "national government" or "state" acts (V. Ostrom, 1991a).⁷ Open political orders in which contestation is the norm can have dramatically different consequences for possible forms of international cooperation than political orders more closely resembling the unaccountable sovereign portrayed in Hobbes's *Leviathan*. In open political systems, for example, groups of individuals are allowed to form various types of associations that would be deemed illegitimate or unlawful in a closed political system. Thus, it would be difficult to rely on NGOs or economic corporations as monitors in any international regimes among Hobbesian sovereigns. Such associations would be encouraged in regimes formed by governments of open political orders. Furthermore, the state-centered monitoring activities characteristic of a Hobbesian system may remain insufficient to sustain global cooperation on controversial issues, since there is no reason to expect that sovereign states would always provide accurate information on their own activities.

Any international regime that includes governments of very different political orders suffers from additional complications. This difficulty is most apparent in regimes covering North-South relations. Many governments in the Third World are based on non-tax sources of revenues (national revenues obtained largely from rents, concessions, and/or donors), hidden taxes, and/or brute force. Government officials, who do not need to rely on the *consent* of taxpayers and obtain substantial revenue from mineral sales and from selling agricultural produce at world market prices (while buying at lower controlled prices), face fewer incentives to invest resources efficiently to generate real economic growth than do governments that are answerable to citizen-taxpayers. When large quantities of donor funds are added to the fiscal resources of a central government, centralized opportunities to seek rents increase still further (Bates, 1983). Amos Sawyer, reflecting on the emergence of autocracy in Liberia stresses the perverse effect of over-reliance on obtaining revenues from forest concessions:

The impact of these arrangements on the society was profound. First, they increased the capability of the government in a manner that further strengthened institutional capacities at the center. The proprietary role of the government—the president, in other words—was enormously increased. Reliance on rents, royalties, and profits gave the presidency an independent existence, with the capability to operate without any of the pretensions of accountability that would have been required had the president been dependent on income or other taxes raised directly from the people (Sawyer, 1992: 261).

There are two problems at the international level when some of the national participants rely heavily on rents for revenue—particularly when these rents are based on forest products. It is not just that these national governments have a delicate political issue to face in limiting the extraction of forest resources. Such an action might eliminate the major source of revenue to the government itself. Furthermore, if a government has not yet established accountability to its own citizens, it is hard to know how to develop trust and accountability at an international level.

Additional Considerations

One important means of resolving conflict within an existing regime is to make adjustments in the rules of that regime. Any examination of the circumstances under which institutional changes will be implemented also requires attention to fundamental questions of institutional design. In this paper we have restricted our attention to the international relevance of some of the characteristics of CPR regimes that manage to continue in operation for long periods of time. It should also be possible to draw additional lessons from the second type of explanation developed in Chapter 6 of *Governing the Commons*, that is, questions concerning the variables that are likely to affect institutional choice processes.

In particular, any systematic survey of international regimes would also have to address the following questions:

1. How many actors are involved? Two, a few, or many?
2. Do actors have common or complementary interests? Are the actors relatively symmetric in resources and perceptions? Or do gross inequities exist in these areas? Do actors share a common understanding of the issues?

3. Was the regime established by a single hegemonic power? Or by a small group of leaders in that field of endeavor, after they had attained their position of leadership? Or was it established before oligopolistic position (or its equivalent) could be attained?
4. What are the procedures for change in membership? Do new members qualify by attaining recognition as a sovereign state? Or must they engage in some qualifying activities? Must current members vote on admission of new members?
5. How are rules established and altered? Can rules be changed during regular meetings of representatives of participating parties? Or must special global conventions be held?
6. What arenas exist for the resolution of disputes? How are decisions enforced on the parties? How likely is it that disputing parties will resort to military force?

Discussion of a few examples may be useful. Bilateral regimes include relations between adversaries (U.S.-Soviet arms control) and allies (demilitarization of the U.S.-Canadian border). Antarctica is a classic example of a regime established by a relatively symmetric group of leading states that took control before the rest of the world could get involved; only those governments actively engaged in Antarctic research can qualify for participation in Antarctic governance. The Law of the Sea involves all countries of the world, and it is a rare example of efforts to impose regulations on an emerging technology (deep seabed mining) before it can establish its own practices. The Law of the Sea emerged from some 15 years of complex global negotiations, but the Ozone Convention required considerably less time to complete and to revise towards stricter standards.

In summary, the basic ideas underlying the analytical framework presented here are that those international regimes that are most effective are likely to have been established by interested parties with common or complementary interests, shared cognitive understandings, and who are relatively symmetric in their capabilities. But probably the most important point is that a successful regime must inspire those actors most directly affected by that regime to engage in regular monitoring activities. Actors should also have access to a graduated scale of sanctions, flexible procedures for revising rules, and a well-established arena for resolution of the disputes that will inevitably arise. In

the international arena the diversity of actors greatly complicates analysis, and considerable research must be completed before the utility of this theoretical framework can be adequately assessed.

Towards Richer Formal Models of International Regimes

Simple 2x2 game models, especially of Prisoner's Dilemma, Chicken, and various coordination games, have proven to be very useful devices for highlighting some fundamental dilemmas of collective action. One can draw on many of the recent developments in game theory, public choice theory, and micro-economic theory to go beneath the surface of an "issue area" in an attempt to isolate structures of situations that occur in many different guises and forms across different issue areas.

A particularly influential body of research focuses on lessons drawn from simple game models in which self-interested or egoistic actors cooperating in the absence of any centralized authority. Influential works by Axelrod (1984) and Oye (1985) emphasize that cooperation (in repeated Prisoner's Dilemma games) is facilitated in situations involving a small number of actors with common or complementary interests and who perceive a long shadow of the future (or low discount rate). Cooperation can also be facilitated by increasing the transparency of a regime (meaning the extent to which individual behavior can be monitored and sanctions focused on rule violators). Other modelers examine the implications of various factors on the range of equilibria solutions for these simple models. For example, a wider range of cooperative behavior becomes feasible if players are allowed to link their behavior in different issue areas (E. Haas, 1980; McGinnis, 1986) or have access to some means of informally correlating their behavior (McGinnis and Williams, 1991).

Lessons drawn from these models should be applied with care. Nearly all game models suppose that the 2 (or n) players are fundamentally symmetric in the sense that they play similar roles (see Gardner and Ostrom, 1991). Although game players differ in their exact preferences and in their

relative resource endowments, they typically have the same or similar set of possible actions. More generally, regimes may include a diverse set of actors, with very different interests and capabilities.

While the n-person, iterated Prisoner's Dilemma game has frequently been equated to the commons problems (as if there were only one commons problem), a much richer array of specific n-person games are found in situations that have the two initial attributes of CPRs. Depending upon the specific rules-in-use, CPR problems can be represented as rent dissipation problems, assignment problems, and technological externality problems. Some of these "typical" structures found in CPR situations lend themselves both to mathematical modeling (see, for example, Gardner and Ostrom, 1991; Weissing and Ostrom, 1991a, 1991b) and to empirical research conducted in an experimental laboratory (see E. Ostrom, Gardner, and Walker, 1992, forthcoming; Walker, Gardner, and Ostrom, 1991; Walker and Gardner, forthcoming; and Walker and Ostrom, 1991).

More elaborate extensive form game models have recently been used to model the variety of monitoring activities that can be used to maintain stable common-pool resources regimes in situations in which rule violations cannot be entirely eliminated (Weissing and Ostrom, 1991a, 1991b). These latter models demonstrate that it is often effective to combine different types of monitoring activities, with individuals playing specialized monitoring roles being supplemented by self-monitoring by the individuals most directly involved. Since there is no way to eliminate all temptation for shirking on the part of monitoring officials, it is useful for the individuals involved to also monitor the level of effort exerted by officials selected to do the monitoring. Even then, rule violations are not totally eliminated, but their effects are sufficiently constrained to allow the overall regime to remain in operation. In short, equilibrium solutions do not require perfect cooperation.

The monitoring models of Ostrom and Weissing suggest important lessons for the regime literature, which to this point has emphasized lessons drawn from much simpler game models containing only a single type of actor. The self-monitoring activities of national governments remain

very important, even when an intergovernmental organization is established to monitor compliance with some specific agreement. But in practice, the most effective monitors of compliance with international trade agreements, for example, are not national governments themselves but rather those economic corporations seeking to prevent their competitors from gaining an unfair advantage by circumventing domestic laws or international treaties.

Our purpose in presenting this preliminary typology of international regimes is to suggest that a much wider range of possibilities exists than has generally been realized in the current literature on models of international regimes. Although the activities of corporations and interest groups receive considerable attention in case studies, formal models of international cooperation continue to focus on a single, undifferentiated set of actors. At best, models of verification procedures include two types of actors, one deciding whether or not to cheat and the other trying to detect and punish rule violations (as in Brams and Kilgour, 1988; Wittman, 1989). Or standard economic games are used in which a hegemon is treated as a monopolist contending with possible entrants (as in Alt, et al., 1988). On the other hand, richly detailed case studies of specific regimes that incorporate the actions of a wide range of actors generally lack a coherent, well-articulated theoretical framework that makes sense of systematic differences in the interests and capabilities of different actor types.

In our opinion, to fairly model the variety of configurations available for use in designing international regimes the goals and behavior possibilities characteristic of each of the following actor types would have to be specified:

- Governments: Open political orders
Coercive political orders
Concession economy-based
- Corporations: Domestic and MNCs
- NGOs and INGOs
- IGOs

Unfortunately, we cannot point to any examples of multiple-actor-type models of international regimes, but we strongly encourage their development. Consider, for example, the problem of monitoring compliance with emissions standards that might be established as part of a global climate regime. If corporations find that compliance with some of these controls would lower their profits, they are likely to seek some way of circumventing them. Yet, other aspects of the regulations might have relatively little effect on profit margins and yet more direct impact on environmental degradation. A corporation's competitors would be particularly concerned about violations that would unfairly lower costs of production, whereas nongovernmental environmental groups would be particularly concerned with violations that adversely affect the environment, whether or not they affect prices.

A model of a game with multiple monitors could be set up, in which corporate competitors would receive benefits from uncovering the first type of violations, and NGOs could receive benefits (through increased exposure to potential contributors or providing satisfaction to their current members) by detecting the second type of violations. As discussed earlier, a multiplicity of contending actors is desirable. Any single organization, whether an IGO or state agency or a private environmental group, that was assigned exclusive responsibility for monitoring would provide a strong incentive for bribery. Also, if all monitoring activities were carried out by the corporations themselves, then it is likely that collusion would result in poor enforcement of the rules.

An additional step might be added to represent the ability of conflict resolution mechanisms to correctly determine whether or not violations had actually occurred. Officials of the conflict resolution arenas (whether representatives of governments, IGOs, or other institutions) would have an incentive to keep the proportion of correct judgements sufficiently high to insure a continued perception of the entire scheme as fair and equitable, but they may also be subject to the temptations of bribes to overlook certain violations. A formal model of this monitoring scheme might help clarify

the extent to which multiple types of monitoring activities can be combined to achieve lower equilibrium rates of cheating, or other properties.

This informal sketch suggests that considerable insights might be derived from very simple models of international regimes in which these different actor types interact on a regular basis, even if only a few types are included in any given model. Such models might help specify circumstances under which different arrangements most effectively enhance the prospects for stable patterns of cooperation. Empirical analyses can suggest the range of possibilities that have already been realized in various circumstances, but formal models complement empirical-based studies by giving them a broader and more rigorous foundation.

Conclusions

In this paper we have drawn lessons from a wide range of research traditions. This survey of institutional research on local commons and on international regimes should lead one to be cautious about insisting on global steps towards global solutions. The most important institutional changes for coping more effectively with political, economic, and environmental issues at the global level may be the development of open information and communication regimes to enhance the capabilities of actors at many levels to come to a better common understanding of both the physical as well as the economic and social aspects of global climate patterns. Global steps may well be accomplished most effectively if many small steps are taken first, providing these steps can be sustained and complement wider efforts.

Notes

1. See E. Ostrom, 1990; Gardner, Ostrom, and Walker, 1991; Gardner and Ostrom, 1991; Tang, 1992; Blomquist, 1992; National Research Council, 1986; McCay and Acheson, 1987; Berkes, 1989; Pinkerton, 1989; V. Ostrom, Feeny, and Picht, 1988.

2. Hardin also contributed to the contemporary presumption that there were only two solutions to this kind of problem. The "only" alternatives that he saw to the commons was what he called "a private enterprise system," on the one hand, or "socialism" on the other (Hardin, 1978: 310). He proposed that change would need to be institute with whatever force was needed. 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" (ibid.: 314). Contrary to many casual, contemporary descriptions, the English commons was not an open access, CPR (see Dahlman, 1980). For a recent re-evaluation, see Feeny, et al., 1990.

3. We do not think it is possible to elucidate necessary AND sufficient principles for enduring institutions as it takes a fundamental willingness of the individuals involved to make any institution work. No set of logical conditions are sufficient to insure that all sets of individuals are willing and able to make an institution characterized by such conditions work.

4. These principles are drawn from E. Ostrom (1990) and are explained in more detail therein.

5. Monitoring problems plague many efforts to understand patterns of global warming. The hypothesis that global warming was responsible for the "bleaching" of coral reefs in the Caribbean can not be established due to the lack of adequate data. Researchers are calling for a major monitoring effort but point out that the number of different variables required and the number of sites required would lead to a monitoring effort that would cost millions of dollars a year (see Roberts, 1991).

6. This logic is similar to procedures used in allocation of the electromagnetic frequency spectrum: the ITU allocates frequency ranges to national governments which then allocate specific frequencies to local broadcasters, according to their own rules and procedures. In the U.S., this allocation is carried out by the FCC and broadcasters closely monitor each other's behavior.

7. See Nietschmann (1991) who examines the historical struggle of the Miskito Indians to retain control over what they consider to be their own territory and resource base by a "foreign" state even though it is this "state" that is recognized in the international realm.

Bibliography

- Alt, James E., Randall L. Calvert, and Brian D. Humes. 1988. "Reputation and Hegemonic Stability: A Game-Theoretic Analysis," *American Political Science Review*, 82:445-466.
- Ashby, W. Ross. 1960. *Design for a Brain: The Origin of Adaptive Behavior*. 2d. ed. New York: Wiley.
- Axelrod, Robert. 1984. *The Evolution of Cooperation*. New York: Basic.
- Bates, Robert. 1983. *Essays on the Political Economy of Rural Africa*. Berkeley: University of California Press.
- Beardsley, Tim. 1992. "Night Heat," *Scientific American* 266 (Feb.): 21-24.
- Berkes, Fikret. 1989. *Common Property Resources: Ecology and Community-Based Sustainable Development*. London: Belhaven Press.
- Blomquist, William. 1992. *They Prefer Chaos: The Evolution of Groundwater Institutions in Southern California*. San Francisco, Calif.: Institute for Contemporary Studies Press.
- Brams, Steven J. and D. Marc Kilgour. 1988. *Game Theory and National Security*, New York: Basil Blackwell.
- Bromley, Daniel W. 1991. "Sustaining the Global Commons: Environmental Policies Through International Cooperation." Paper prepared for the Agency for International Development, Bureau for Science and Technology, Office of Rural Development. Madison, Wisconsin: Department of Agricultural Economics.
- Bull, Hedley. 1977. *The Anarchical Society*. New York: Columbia University Press.
- Carnesale, Albert, and Richard N. Haass, eds. 1987. *Superpower Arms Control*. Cambridge, Mass.: Ballinger.
- Charlson, R. J., et al. 1992. "Climate Forcing by Anthropogenic Aerosols." *Science* 255 (Jan. 24): 423-30.
- Clark, Colin W. 1980. "Restricted Access to Common-Property Fishery Resources: A Game-Theoretic Analysis." In *Dynamic Optimization and Mathematical Economics*, ed. Pan-Tai Liu, 117-32. New York: Plenum Press.
- Cleveland, Harlan. 1990/91. "The Management of Peace." *The GAO Journal* (Winter 1990/91):4-23.
- Commission on Geosciences, Environment, and Resources. 1991. *Rethinking the Ozone Problem*. Washington, D.C.: National Research Council.

- Copes, Parzival. 1986. "A Critical Review of the Individual Quota as a Device in Fisheries Management." *Land Economics* 62(3):278-91.
- Cruz, Maria Concepcion. 1991. "Population Pressure, Deforestation, and Common Property Institutions: An Overview." Paper presented at the Second Annual Meeting of the International Association for the Study of Common Property (IASCP), Winnipeg, September 26-29.
- Dahlman, Carl J. 1980. *The Open Field System and Beyond: A Property Rights Analysis of an Economic Institution*. Cambridge: Cambridge University Press.
- De Alessi, Louis. 1988. "How Markets Alleviate Scarcity." In *Rethinking Institutional Analysis and Development: Issues, Alternatives, and Choices*, ed. Vincent Ostrom, David Feeny, and Hartmut Picht, 339-76. San Francisco, Calif.: Institute for Contemporary Studies Press.
- Dorfman, Robert. 1991. "Protecting the Global Environment: An Immodest Proposal." *World Development* 19(1): 103-10.
- Feeny, David, Fikret Berkes, Bonnie J. McCay, and James M. Acheson. 1990. "The Tragedy of the Commons: Twenty-Two Years Later." *Human Ecology* 18(1): 1-19.
- Gaddis, John Lewis. 1987. "Learning to Live with Transparency: The Evolution of a Reconnaissance Satellite Regime." In *The Long Peace*, 195-214. New York: Oxford University Press.
- Gardner, Roy, and Elinor Ostrom. 1991. "Rules and Games." *Public Choice* 54:171-85.
- Gardner, Roy, Elinor Ostrom, and James Walker. 1991. "The Nature of Common-Pool Resource Problems." *Rationality and Society* 2(3) (July):335-58.
- Gordon, H. Scott. 1954. "The Economic Theory of a Common Property Resource: The Fishery." *Journal of Political Economy* 62 (April): 124-42.
- Haas, Ernst B. 1980. "Why Collaborate? Issue-Linkage and International Regimes." *World Politics* 32:357-405.
- Haas, Peter M. 1989. "Do Regimes Matter? Epistemic Communities and Mediterranean Pollution Control." *International Organization* 43:378-403.
- _____. 1990. *Saving the Mediterranean: The Politics of International Environmental Cooperation*. New York: Columbia University Press.
- _____, ed. 1992. *Knowledge, Power, and International Policy Coordination*, special issue of *International Organization* 46:1 (Winter 1992).
- Hardin, Garrett. 1968. "The Tragedy of the Commons." *Science* 162:1,243-248.
- _____. 1978. "Political Requirements for Preserving our Common Heritage." In *Wildlife and America*, ed. H. P. Bokaw, 310-17. Washington, D.C.: Council on Environmental Quality.

- Hurwicz, Leonid. 1973. "The Design of Mechanisms for Resource Allocation." *American Economic Review* 63(2): 1-30.
- Jackson, John H. 1990. *Restructuring the GATT System*. New York: Council of Foreign Relations Press (London: The Royal Institute of International Affairs).
- Jacobson, Harold K. 1984. *Networks of Interdependence*. 2d ed. New York: Knopf.
- Keohane, Robert O. 1980. "The Theory of Hegemonic Stability and Changes in International Economic Regimes, 1967-1977." In *Change in the International System*, ed. Ole Holsti, Randolph Siverson, and Alexander George, 131-62. Boulder, Colo.: Westview Press.
- _____. 1984. *After Hegemony*. Princeton, N.J.: Princeton University Press.
- Kiser, Larry L., and Elinor Ostrom. 1982. "The Three Worlds of Action: A Metatheoretical Synthesis of Institutional Approaches." In *Strategies of Political Inquiry*, ed. Elinor Ostrom, 179-222. Beverly Hills, Calif.: Sage.
- McCay, Bonnie J., and James M. Acheson. 1987. *The Question of the Commons: The Culture and Ecology of Communal Resources*. Tucson: University of Arizona Press.
- McGinnis, Michael D. 1986. "Issue Linkage and the Evolution of International Cooperation." *Journal of Conflict Resolution* 30:141-70.
- McGinnis, Michael D., and Elinor Ostrom. 1992. "Linking Local and Global Commons: Design Principles for Robust International Regimes." Paper presented at the conference on "Global Climate Change and International Security II," sponsored by The Midwest Consortium for International Security Studies and Argonne National Laboratory, held at the Argonne National Laboratory, Chicago, Illinois, February 11-13.
- McGinnis, Michael D., and John T. Williams. 1991. "Configurations of Cooperation: Correlated Equilibria in Coordination and Iterated Prisoner's Dilemma Games." Paper presented at the Twenty-Fifth North American Meeting of the Peace Science Society (International), University of Michigan, Ann Arbor, Michigan, November 15-17, 1991.
- Moe, Terry M. 1984. The New Economics of Organization, *American Journal of Political Science*, 28:739-777.
- _____. 1989. The Politics of Bureaucratic Structure. In *Can the Government Govern?* edited by John E. Chubb and Paul E. Peterson, Washington: Brookings.
- National Research Council. 1986. *Proceedings of the Conference on Common Property Resource Management*. Washington, D.C.: National Academy Press.
- Neitschmann, Bernard. 1991. "Environmental Conflicts and Indigenous Nations in Central America." Paper presented at the Conference on "Environmental Change and Acute Conflict" Sponsored by

the American Academy of Arts and Sciences and the Peace and Conflict Studies Program of the University of Toronto, September.

Oakerson, Ronald J. 1986. "A Model for the Analysis of Common Property Problems." In *Proceedings of the Conference on Common Property Resource Management*, National Research Council, 13-30. Washington, D.C.: National Academy Press.

Olson, Mancur. 1965. *The Logic of Collective Action*. Cambridge: Harvard University Press.

Ostrom, Elinor. 1986. "An Agenda for the Study of Institutions." *Public Choice* 48:3-25.

_____. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.

_____. 1992. *Crafting Institutions for Self-Governing Irrigation Systems*. San Francisco, Calif.: Institute for Contemporary Studies Press.

Ostrom, Elinor, and Vincent Ostrom. 1977. "Public Goods and Public Choices." In *Alternatives for Delivering Public Services*, ed. E. S. Savas, 7-49. Boulder, Colo.: Westview Press.

Ostrom, Elinor, Roy Gardner, and James Walker. 1992. "Covenants With and Without a Sword: Self-Governance is Possible." *American Political Science Review* (June), forthcoming.

Ostrom, Elinor, Roy Gardner, and James Walker. Forthcoming. *Rules and Games: Institutions and Common-Pool Resources*. Ann Arbor: University of Michigan Press.

Ostrom, Vincent. 1987. *The Political Theory of the Compound Republic: Designing the American Experiment*. Rev. ed. Lincoln: University of Nebraska Press.

_____. 1991a. *The Meaning of American Federalism: Constituting a Self-Governing Society*. San Francisco, Calif.: Institute for Contemporary Studies Press.

_____. 1991b. "Some Ontological and Epistemological Puzzles in Policy Analysis." Paper presented at the Annual Meeting of the American Political Science Association, Washington, D.C., August 30.

Ostrom, Vincent, David Feeny, and Hartmut Picht. eds. 1988. *Rethinking Institutional Analysis and Development: Issues, Alternatives, and Choices*. San Francisco, Calif.: Institute for Contemporary Studies Press.

Oye, Kenneth A., ed. 1985. *Cooperation Under Anarchy*, special issue of *World Politics*, 38:1. Reprinted by Princeton: Princeton University Press, 1986.

Pilat, Joseph F. 1992. "Iraq and the Future of Nuclear Proliferation: The Roles of Inspections and Treaties." *Science* 255 (March 6): 1224-229.

- Pinkerton, Evelyn, ed. 1989. *Co-operative Management of Local Fisheries: New Directions for Improved Management and Community Development*. Vancouver: University of British Columbia Press.
- Plott, Charles R., and Robert A. Meyer. 1975. "The Technology of Public Goods, Externalities, and the Exclusion Principle." In *Economic Analysis of Environmental Problems*, ed. Edwin S. Mills. New York: National Bureau of Economic Research.
- Polanyi, Michael. 1951. *The Logic of Liberty: Reflections and Rejoinders*. Chicago: University of Chicago Press.
- Rawlins, Stephen L. 1991. "Status of our Institutional Capacity to Monitor the Agricultural Production Consequences of Environmental Changes." Paper Commissioned for the Consultation on Institutional Innovations for Sustainable Agricultural Development: Into the 21st Century." Rockefeller Foundation Conference Center, Bellagio, Italy, October 14-18.
- Roberts, Leslie. 1991. "Greenhouse Role in Reef Stress Unproven." *Science* 253:258-59.
- Samuelson, Paul. 1954. "The Pure Theory of Public Expenditure." *Review of Economics and Statistics* 36:387-89.
- Sawyer, Amos. 1992. *The Emergence of Autocracy in Liberia: Tragedy and Challenge*. San Francisco, Calif.: Institute for Contemporary Studies Press.
- Schaefer, Milner. 1957. "Some Considerations of Population Dynamics and Economics in Relation to the Management of the Commercial Marine Fisheries." *Journal of the Fisheries Research Board of Canada* 14:669-81.
- Schlager, Edella. 1990. "Model Specification and Policy Analysis: The Governance of Coastal Fisheries." Ph.D. diss., Indiana University, Bloomington.
- Scott, Anthony. 1962. "The Economics of Regulation Fisheries." In *Economic Effects of Fishery Regulation*, ed. R. Hamlich, 22-61. Rome: Food and Agriculture Organization.
- _____. 1979. "Development of Economic Theory of Fisheries Regulation." *Journal of the Fisheries Board of Canada* 36:725-30.
- _____. 1982. "Regulation and the Location of Jurisdictional Powers: The Fishery." *Osgoode Hall Law Journal* 20:780-805.
- Sebenius, James K. 1984. *Negotiating the Law of the Sea: Lessons in the Art and Science of Reaching Agreement*. Cambridge, Mass.: Harvard University Press.
- _____. 1991. "Designing Negotiations Toward a New Regime: The Case of Global Warming." *International Security* 15(4): 110-48.

- Shepsle, Kenneth A. 1979a. "Institutional Arrangements and Equilibrium in Multidimensional Voting Models." *American Journal of Political Science* 23(1):27-59.
- _____. 1979b. "The Role of Institutional Structure in the Creation of Policy Equilibrium." In *Public Policy and Public Choice*, ed. Douglas W. Rae and T. J. Eismeier, 249-83. Sage Yearbooks in Politics and Public Policy 6. Beverly Hills, Calif.: Sage.
- _____. 1989. "Studying Institutions: Some Lessons from the Rational Choice Approach." *Journal of Theoretical Politics* 1:131-49.
- Tang, Shui Yan. 1992. *Institutions and Collective Action: Self-Governance in Irrigation*. San Francisco, Calif.: Institute for Contemporary Studies Press.
- Townsend, Ralph E. 1986. "A Critique of Models of the American Lobster Fishery." *Journal of Environmental Economics and Management* 13:277-91.
- Townsend, Ralph E., and James Wilson. 1987. "An Economic View of the 'Tragedy of the Commons'." In *The Question of the Commons: The Culture and Ecology of Communal Resources*, ed. Bonnie J. McCay and James M. Acheson, 311-26. Tucson: University of Arizona Press.
- Victor, David G. 1991. "Limits of Market-Based Strategies for Slowing Global Warming: The Case of Tradeable Permits." *Policy Sciences* 24:199-222.
- Walker, James M., and Roy Gardner. Forthcoming. "Rent Dissipation and Probabilistic Destruction of Common Pool Resources: Experimental Evidence." *Economic Journal*. In Press.
- Walker, James M., Roy Gardner, and Elinor Ostrom. 1991. "Rent Dissipation and Balanced Deviation Disequilibrium in Common Pool Resources: Experimental Evidence." In *Game Equilibrium Models II: Methods, Morals, and Markets*, ed. Reinhard Selten, 337-67. Berlin: Springer-Verlag.
- Walker, James M., and Elinor Ostrom. 1991. "Communications in a Commons: Cooperation with External Enforcement." In *Laboratory Research in Political Economy*, ed. Thomas R. Palfrey, 287-322. Ann Arbor: University of Michigan Press.
- Weissing, Franz, and Elinor Ostrom. 1991a. "Irrigation Institutions and the Games Irrigators Play: Rule Enforcement without Guards." In *Game Equilibrium Models II: Methods, Morals, and Markets*, ed. Reinhard Selten, 188-262. Berlin: Springer-Verlag.
- Weissing, Franz, and Elinor Ostrom. 1991b. "Irrigation Institutions and the Games Irrigators Play: Internal versus External Rule Enforcement." Paper presented at the Workshop on Games in Hierarchies and Networks at the Max-Planck-Institut für Gesellschaftsforschung in Köln, September 5-7.
- Wilson, James A. 1982. "The Economical Management of Multispecies Fisheries." *Land Economics* 58(4):417-34.

Wittman, Donald. 1989. "Arms Control Verification and Other Games Involving Imperfect Detection," *American Political Science Review*, 83:923-945.

Young, Oran R. 1989. "The Politics of International Regime Formation: Managing Natural Resources and the Environment." *International Organization*, 43:349-75.

Figure 1. Classification of Actor Types

<u>Primary Arena of Activity</u>	<u>Scope of activities</u>	
	Domestic	International
Political	National governments Other bureaucratic agents	IGOs
Economic	Domestic corporations	MNCs
Epistemic	NGOs technical experts	INGOs epistemic communities

Figure 2. An Actor-Based Classification of International Regimes

	<u>who gets sanctioned?</u>		
	governments	corporations	private groups or individuals
<u>who monitors?</u>			
governments	1 arms control laws of war	4 LDC-MNC relations	8 war crimes NIIO
IGOs	2 nuclear non- proliferation	5 seabed mining (Law of the Sea)	
corporations	3 trade restrictions frequency spectrum	9 cartels	
private groups or individuals	6 human rights environmental	7 future environmental?	