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DESIGN PRINCIPLES OF ROBUST PROPERTY-RIGHTS INSTITUTIONS: WHAT HAVE WE LEARNED?

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The Problem of Open Access

The problem of overuse of open-access resources was clearly articulated by Scott Gordon (1954) and Harold Demsetz (1967). Garrett Hardin (1968) speculated about the same problem, but stressed that the resource users themselves were trapped in tragic overuse and that solutions had to be imposed on them from the outside. Gordon, Demsetz, and Hardin ignited a general concern that when property rights did not exist related to a valuable resource, the resources would be overharvested.

Sufficient empirical examples existed where the absence of property rights and the independence of actors captured the essence of problems facing users of land-based common-pool resources that the empirical applicability of the theory was not challenged until the mid-1980s. The massive deforestation in tropical countries and the collapse of many ocean fisheries confirmed the worst predictions to be derived from this theory for many (Rudel 2005; Hutchings 2000; Jackson et al. 2001). Since harvesters are viewed as being trapped in these dilemmas, repeated recommendations have been made that external authorities *must* impose a different set of institutions on such settings. Predictions of overharvesting are also supported in the experimental laboratory when subjects make anonymous decisions and are not allowed to communicate with one another, but not when they are able to engage in face-to-face communication (Ostrom, Gardner, and Walker 1994).

Solving the Problem by Recommending Optimal Institutions

Many policy analysts recommend a single "optimal" policy for solving the open-access problem. Some recommend private property as the most efficient form of ownership as did Demsetz himself (Raymond 2003; Posner 1977). Others recommend government ownership and control (Terborgh 1999, 2000; Lovejoy 2006) even though it is difficult for a bureaucracy to make "rational" decisions given the high level of uncertainty involved in most resources (Whitford 2002). Grafton (2000) makes a more nuanced argument for "the state" in governing resources—sometimes as the owner of a resource and sometimes providing good backup to those who are engaged in collective action. Implicitly, theorists frequently assume that regulators will act in the public interest and know how ecological systems work and how to change institutions so as to induce socially optimal behavior (Feeny, Hanna, and McEvoy 1996: 195).

Unfortunately, many of the recommended "optimal" institutions are little more than stylized figures based on the underlying simple models that Gordon and Demsetz developed. Colin Clark (2006: 15) reflects on the power of these simple models to illustrate very clearly the deep problems of overharvesting. The underlying "stick figures," however, are too simplistic for analysis that adequately captures the dynamics of all common-pool resources. Applying rules that bring the costs of harvesting up to the level that would "induce" sustainable yield is a simple solution when modeling, but not at all simple when faced with the complexity of field settings.

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Self-Organized Development of Property Rights

The possibility that the users of a resource would find ways to organize themselves was not considered in most economics, natural resource, and property-rights literature until the last three decades. Organizing so as to create rules that specify rights and duties of participants creates a public good for those involved. Anyone who is included in the community of users benefits from this public good, whether they contribute or not. Thus, getting "out of the trap" is itself a second-level social dilemma. Investing in diverse mechanisms to increase the likelihood that participants follow the rules they make also generates a public good. Thus, these investments represent a third-level social dilemma. Since the initial problem exists because the individuals are supposed to be stuck in a setting where they generate negative externalities on one another, it is not consistent with the conventional theory that they solve a second- and third-level social dilemma in order to address the first-level dilemma under analysis.

In the decades after Scott's, Demsetz's, and Hardin's famous articles, however, multiple empirical studies about common-pool resources have been undertaken (NRC 1986, 2002; Berkes 1989, 2007; McCay and Acheson 1987; Dolšak and Ostrom 2003). As a result of these studies, we now know that *some* (but not all) of those individuals who jointly use a common-pool resource will:

> Expend considerable time and energy trying to develop workable rules that they can use for governing and managing a resource;
>
> Follow their own costly rules so long as they believe that most of the others affected also follow these rules;
>
> Monitor each other's conformance with these rules; and
>
> Impose sanctions on those who break rules at a cost to themselves.

Conventional economic theory would not lead to a prediction that anyone would undertake these four actions based on a model of maximization of short-term individual returns. Thus, to move our understanding ahead of earlier theories, it is necessary to dig into what we mean by property rights and how resource users may design their own property-rights systems. Then, we will need to examine an earlier effort to understand why some property-rights systems were robust over long periods of time while others collapsed—the possibility that broad design principles underlay the successful efforts (Ostrom 1990). We will then discuss a recent analysis of studies by scholars regarding their assessment of the usefulness of these design principles and conclude with an analysis of how the design principles should be revised in light of multiple studies and how we can use the design principles in practice without using them as "blueprints."

What are Property Rights?

One of the confusions related to the existence of property rights is that scholars have sometimes limited the concept of property right to the existence of a right by one party (individual, family, organized group, or government) to sell all of the rights to some other party.

Selling one's rights is frequently referred to as alienation. Some scholars presumed that unless users had alienation rights, they did not have *any* property rights. Some of the early confusion about the capability of users to develop their own effective governance system related to the presumption that without the right of alienation, resource users had no property rights and were indeed trapped in overuse. After the first National Research Council report in 1986, we began collecting case studies written by historians, anthropologists, engineers, political scientists, economists, and other social scientists and started the challenging task of coding them systematically in the "CPR database" (see Schlager 1990; Tang 1992; Ostrom, Gardner, and Walker 1994 for a general description of the effort, and Poteete and Ostrom 2008 for an overview of the challenge of doing a meta-analysis of the large number of relevant cases).

As we worked on this meta-analysis of governance systems related to common-pool resources, we kept finding established resource systems that had survived for long periods of time where the users did not have the right to sell their holdings. This led Edella Schlager and myself (1992) to draw on the earlier insights of Ciriacy-Wantrup and Bishop (1975) and John R. Commons (1968) to think of property-rights systems in regard to *bundles* of rights rather than a single right. We defined a series of five rights that we found in empirical studies of operational resource systems in the field. These are:

> Access—a right to enter a defined physical property.
>
> Withdrawal—a right to harvest the products of a resource such as timber, water, or food for pastoral animals.
>
> Management—a right to regulate the use patterns of other harvesters and to transform a resource system by building improvements.
>
> Exclusion—a right to determine who else will have the right of access to a resource and whether that right can be transferred.
>
> Alienation—a right to sell or lease any of the above for rights.

Schlager and Ostrom (1992) posed the possibility that one can relate the different ways that these bundles are combined to a set of positions that individuals hold in regard to operational settings. For many resources, one can define five types of positions that people hold who have some type of a property right and obligations that are related to that right. If a person has only access rights, one could call them an authorized viewer. When a person enters a national or state forest, for example, with a one-day (or one-season) permit, they have a property right as an authorized viewer. They may have had to pay a fee to obtain this right, and they have other obligations to follow the rules established by forest authority. Most state forests, for example, do not allow people who have a day or monthly permit to harvest anything from a state forest. They can sit at picnic grounds and enjoy the forest, but they are not supposed to litter the forest. They may be authorized to camp overnight. They can do all sorts of viewing, but they are not supposed to harvest trees, mushrooms, or other plants or to litter the forest.

When a person has access and withdrawal rights, one can call them an authorized user. In many pastoral systems and fisheries, users have evolved recognized rights to harvest. Frequently, those rights are matched with obligations in regard to the timing of harvest, the equipment that may be used in harvesting, and the purpose that the harvested units may be used. A person with access, withdrawal, and management rights, we called a claimant. Again, many common-property institutions do recognize the rights and obligations of "claimants" to build fences around a jointly owned forest, to improve an irrigation system by lining the canals, or any of a wide diversity of improvements that could be made that relate to the management of the system. The obligations involved in these property rights do enable the holders to achieve a longer-term perspective as a result of the investments they make in the long-term productivity and sustainability of the resource.

When a person has those three rights plus the right of exclusion, we called them a proprietor. A proprietor has substantial rights and obligations to regulate use, invest in the system, and determine who else has access to the system. Finally, we used the term "owner" for individuals who have all five rights and obligations related to these rights. There are a variety of common-property institutions where participants can sell any and all of their other bundles of rights to someone else. Sometimes, they have to get permission from a council to do this, but they have that right subject to review. There are, however, many well-defined and operational common-property systems that have existed for a long time without the right of alienation (Netting 1981; McKean 1982, 1992).

Schlager (1994) analyzed the patterns of rights and outcomes for a set of inshore fishery cases that were well documented by the original case authors. Schlager found that possessing at least the three rights held by a claimant (access, withdrawal, and management) did affect the capabilities of fishers from inshore fisheries to self-organize. Having the authority to exclude others (being a proprietor) gave fishers even more capabilities to ensure that others did not invade their inshore fishery and allowed still further investment in regulating use and investment. She did not find that having the right of alienation was as essential as claimed in the literature. In regard to irrigation systems, Tang (1994) found that having the rights of a proprietor made a substantial difference in regard to the long-term management, but having the full rights of an owner was not crucial. In many common-property systems that have been sustained over long periods of time, none of the resource users has had the right to alienate their other rights. Thus, the right of alienation is *not* the key defining right for those who have been responsible for design and adapting common-property systems in the field. Many users of common-pool resources do have property rights even though these may not include the right of alienation.

Can Resource Users Create their *Own* Property Rights?

While Hardin presumed that the users of a common-pool resource were hopelessly trapped in a system of overuse, the extensive research literature on common-property institutions (see overview in NRC 1986, 2002) provides strong evidence that the users are not always helpless. In some legal systems—particularly those broadly based on Roman law traditions rather than English common law—the extent of autonomy granted to users of forests, irrigation systems, lakes, and inshore fisheries to develop their own property-rights systems is restricted. Even in these systems, however, users of common-pool resource systems located in relatively remote settings have frequently (but, not always) established some basic understanding of who

was authorized to use the resource, how resource units should be harvested from the resource, and the agreed-upon uses of these resources.[1]

To create their *own* set of rules about boundaries and use practices, a group of users must solve a basic collective-action problem—the second-level social dilemma that I referred to above (Leach, Mearns, and Scoones 1997; Mehta et al. 1999). They face a long-term problem that if they do not find a way of limiting use, they will destroy a resource that may be of high value to the users in terms of their own personal and family economic well being. Just facing such a problem is, however, not a sufficient condition for positing that users will engage in collective action. Many theorists have presumed, as Hardin did, that those involved in a collective-action problem would not *themselves* solve it since social dilemmas involve a conflict between individual rationality and optimal outcomes for a group (Coase 1960; Alchian and Demsetz 1972; Schelling 1978; Lichbach 1996). Even if some individuals cooperate, the others are predicted to "free-ride" on those who cooperate.

In formal models of social dilemmas, assumptions are made that (1) decisions about strategies are made independently and simultaneously, (2) participants have common knowledge of an exogenously fixed structure of the situation and of the payoffs to participants, and (3) no external authority is present to enforce agreements among participants about their choices. When these assumptions are made for a one-shot game, the theoretical prediction derived from classical, noncooperative game theory is unambiguous—zero cooperation.[2] In repeated situations, there are many solution concepts that vary all the way from zero to full cooperation (Abreau 1988).

Fortunately, collective-action theory has now matured. Instead of predicting that participants will never engage in cooperation or predicting that "anything can happen," there is growing agreement on the attributes of the users and of the structure of the situation in which they find themselves that combines to enable predictions to be made regarding the likelihood of participants engaging in collective action (see Ostrom 2007a for an overview; Gibson et al. 2005; Marshall 2005). Some of the variables considered in the collective-action literature include: the size and heterogeneity of the group involved and how individuals are potentially linked, the type of production functions users are facing, the type of transaction costs that a group faces, how easy it is to get good information about the results of past actions, and how valuable solving the problem is to participants. Developing trust and reciprocity is crucial to building the social capital needed to create workable property rights (Ostrom 1998; Ahn and Ostrom 2008). In this paper, I will not delve into the variables that increase the probability that a group of resource appropriators engages in collective action to create a set of property rights since I have already written about this in several past works (Ostrom 1990, 2001, 2005). Here, I only wish to point out that it is now well established that some users of common-pool resources in settings that are conductive to self-organization do create their *own* common-property institutions.

The Robustness of Self-Organized Common-Property Institutions

Not only have common-property scholars documented the possibility that resource users would themselves overcome dilemmas to create their own institutions, but many of these institutions have survived for multiple years—and even centuries in some instances. In the late 1980s, after working with colleagues to amass, read, and code a large number of individual cases

of long-lasting and of failed systems, I tried valiantly to find the specific rules that were associated with the systems that had survived for long periods of time using Kenneth Shepsle's (1989) definition of a robust institution. Shepsle defined an institution to be robust if it was long-lasting and the operational rules had been devised and modified over time according to a set of higher level rules (which institutional analysts would usually call collective-choice rules). These higher-level rules might themselves be modified slowly over time. The contemporary definition of "robustness" in regard to complex systems focuses on adaptability to disturbances: "the maintenance of some desired system characteristics despite fluctuations in the behavior of its component parts or its environment" (Carlson and Doyle 2002: 2538; see also Anderies, Janssen, and Ostrom 2004; Janssen and Anderies 2007).

I spent weeks and weeks reading cases, writing them up, redoing statistical analysis, and thinking that I was a dope for not being able to identify regularities in the specific property rights of the successful cases. Finally, the idea dawned on me that I should stop trying to identify the *specific* rules that tended to generate success. Perhaps what I needed to do was move up a level or two in generality to try and understand more general institutional regularities among the systems that were sustained over a long period of time. I did not even know what I should call those regularities. The idea finally dawned on me that one way of talking about it would be as "design principles."

I did not think that the irrigators, fishers, forest dwellers, and others who had invented and sustained successful common-property regimes over several centuries had these principles overtly in their minds. Not all artists have training in art and know the principles that they actually do use in painting an outstanding work of art. So I thought of these regularities as underlying principles that one could draw out from the cases of long sustained regimes. Then I compared the successes with the failures to assess whether the failures were characterized by the same principles. If they were, of course, the principle would not be a meaningful distinction between robust, long-surviving systems and systems that were not able to sustain themselves over time.

Thus, in *Governing the Commons* (Ostrom 1990), I laid out what I thought were eight key design principles related to long-term robustness of institutions crafted to govern common-pool resource systems. At the time, I had many colleagues read and comment on this effort and the cases I was using to derive and then illustrate the principles. I was very uncertain that I had indeed identified the core set of principles, but I finally decided that I should share this analysis with other scholars so that they could challenge these findings and we could develop a firmer foundation for better institutions in the future.

The Eight Design Principles Posited in 1990

Since I described these principles in some detail in Ostrom (1990, 2005), I will give only a brief overview of them here as a basis for a further discussion (see Table 1).

<<Insert Table 1 here>>

Well-Defined Boundaries

The first design principle that I articulated is that the boundaries of a resource system, as well as the individuals or households with property rights, are clearly defined. The boundary rules related to who can enter, harvest, manage, and potentially exclude others, impacts on the presumption that a participant has about the likely levels of trustworthiness and cooperation of the others involved. If those rules are not well defined, strangers who discover a valuable resource may start to use it. Because they are strangers, they may simply overuse it. When long-standing participants fear that others may start using a resource of value to them, creating well-defined boundary rules helps immensely in increasing the probability that if one is cooperating in limiting harvests and in providing maintenance, one is not being a sucker because others are overharvesting and not contributing to the maintenance.

Having a clear boundary for the resource itself is important for a different set of reasons. It clarifies what is meant by a particular resource system. Where may I go and where may I not go? The problem that is addressed by systems that do define their boundaries is clearly free-riding. If a group of users can determine their own membership—including those who agree to use the resource according to their agreed-upon rules and excluding those who do not agree to these rules—the group has made an important first step toward limiting access and developing greater trust and reciprocity. Using this principle enables participants to know who is in and who is out of a defined set of relationships and, thus, with whom to cooperate.

Just defining the boundaries carefully, however, may not be sufficient in and of itself, especially when the boundaries are drawn by external officials. The boundaries of the Maya Biosphere Reserve are very well defined on many maps of the reserve located in the capital city of Guatemala, in the relevant national parks, and in many tourist brochures. Sundberg (1998: 402) reports on a survey of residents of an agricultural community in one of the buffer zones of the reserve, however, and finds that almost 80 percent of the farmers did not know anything about the reserve or its boundaries in which they were located (see also the supporting online material for Dietz, Ostrom, and Stern 2003).

Proportional Equivalence between Benefits and Costs

The second design principle is that the rules-in-use allocate benefits proportional to inputs that are required. If a group of users is going to harvest from a resource over the long run, they must devise rules related to how much, when, and how different products are to be harvested. They also need to assess the costs of operating a system on users. The design principle related to proportionality of benefits and costs relates to the likelihood that participants will feel that the rules they are using are equitable. If some people pay low costs but they get high benefits over time, this inequity is a matter of frustration for the participants and may lead to more and more participants refusing to abide by the rules because they are unfair. Thus, this design principle is directly related to the types of attitudes that are necessary to sustain a system over the long run. If some users get all the benefits and pay few of the costs, few of the others are willing to follow rules over time (Ensminger 2000, 2001).

Collective-Choice Arrangements

The third design principle is that most of the individuals affected by a resource regime are authorized to participate in making and modifying their rules. Resource regimes that use this principle should be able to craft rules to fit local circumstances and to devise rules that are considered fair by participants. As environments change over time, being able to craft local rules is particularly important as officials located far away do not know of the change. Some local common-property institutions do empower a local elite to make most of the collective-choice decisions. In such cases, one can expect that the policies adopted primarily benefit the elite and then are not consistent with the second design principle (for example, see Platteau 2003, 2004; Ensminger 1990).

Monitoring

Few long-surviving resource regimes rely only on levels of trust and reciprocity among appropriators to keep rule-breaking levels down. Evidence of the importance of the fourth design principle—monitoring—is presented by Gibson, Williams, and Ostrom (2005); Ostrom and Nagendra (2006); Hayes and Ostrom (2005); and Schweik (2000). A recent multivariant analysis by Coleman and Steed (2008) of 130 forests located in a dozen countries finds that when local forest users are recognized as having a right of harvesting (having at least the position of an authorized user), they are more likely to monitor patterns of harvesting by other appropriators. When this happens, the resource conditions are themselves better than when local users do not monitor each other.

Most institutional analysts do assume that rules must be enforced in some manner to achieve robust governance but not always on who should select the monitors. Most self-organized resource regimes select their own monitors. These monitors are accountable to authorized users and keep an eye on resource conditions as well as on harvesting activities. By creating official positions for local monitors, a resource regime does not rely only on the norms of local right-holders to impose personal costs on those who break a rule. The community creates an official position. In some systems, users rotate into this position so everyone has a duty to be a monitor. In others, the monitors are paid from a fund collected from all authorized appropriators. With monitors appointed, those who want to cooperate with the rules so long as others also cooperate are assured that someone is generally checking on the conformance of others to local rules. No one likes being a sucker! Thus, they can continue to cooperate without the fear that others are taking advantage of them.

Graduated Sanctions

The fifth design principle is the use of *graduated* sanctions. This was one finding that really puzzled me as I had devoted 15 years of empirical research to the study of policing in metropolitan areas and was deeply familiar with the literature on the economics of crime. This literature stressed the importance of costly sanctions so that the expected value of breaking a law was higher than the benefit that could be obtained even when the probabilities of being caught were relatively low. In many self-organized systems, the first sanction imposed by a local monitor is so low as to have *no* impact on the expected benefit-cost ratio of breaking local rules (given the high payoffs that could be achieved by harvesting illegally, for example).

The initial sanction can be thought of more as information to the person who is "caught" as well as to others in the community. A user could always make an error or could face difficult problems leading them to break a rule. Letting an infraction pass unnoticed could generate a downward cascade of cooperation in a group that relies only on conditional cooperation and has no capacity to sanction. When graduated punishments are used, a person who purposely or by error breaks a rule is notified that others notice the infraction (thereby increasing the individual's confidence that others would also be caught). Further, the individual learns that others basically continue to extend their trust and want only a small token to convey a recognition that the mishap occurred.

How Do These Fit Together?

The first five principles fit together to form a rather coherent theoretical explanation of why they may work together:

> When the users of a resource design their own rules (design principle 3) that are enforced by local users or accountable to them (design principle 4) using graduated sanctions (design principle 5) that clearly define who has rights to withdraw from a well-defined resource (design principle 1) and that effectively assign costs proportionate to benefits (design principle 2), collective action and monitoring problems tend to be solved in a reinforcing manner. (Ostrom 2005: 267)

Conflict-Resolution Mechanisms

The sixth principle is that there are rapid, low-cost, local arenas to resolve conflict among users or between users and officials. Rules have to be understood in order to be effective. Some participants may interpret a rule that they have jointly made in different ways. By devising simple, local mechanisms to get conflicts aired immediately and resolutions that are generally known in the community, the number of conflicts that reduce trust can be reduced.

Minimal Recognition of Rights to Organize

Whether local users can develop more effective regimes *over time* is affected by whether they have at least minimal recognition of the right to organize by a national or local government. Participants in resource regimes that are not recognized by external authorities have operated over long periods, but they have had to rely almost entirely on unanimity as the rule used to change rules (see Ghate 2000). Otherwise, disgruntled participants who voted against a rule change can go to the external authorities to threaten the regime itself! Changing rules using unanimity imposes high transaction costs and prevents a group from searching for better-matched rules at relatively lower costs. When external governmental officials presume that *only* they can make authoritative rules, then sustaining a self-organized regime is very difficult (Johnson and Libecap 1982).

Nested Enterprises

When common-pool resources that are being managed by a group are large, an eighth design principle may be present in robust systems. The nested enterprise principle is that governance activities are organized in multiple layers of nested enterprises. In addition to some small units, larger institutions exist to govern the interdependencies among smaller units. The rules allocating water among major branches of an irrigation system, for example, may differ from the rules used to allocate water among farmers along a single distributory channel (Yoder 1994). Consequently, among long-enduring self-governed regimes, smaller-scale organizations tend to be nested in ever larger organizations.

A Current Evaluation of the Validity of the Design Principles

When colleagues at the Lincoln Institute asked me to give this presentation, I thought that this might be a good time to evaluate systematically whether the design principles were a useful way of capturing the basic underlying elements of successful, long-surviving common-property institutions. When I sought to identify the design principles, I did not know whether I had discovered anything of long-term value. I was simply struggling with a way of understanding what held some systems together better than others. There have been scholars who have sent me papers that illustrated that the design principles did characterize sustainable resource and institutional systems that they had indeed studied and I described some of these in chapter 9 of *Understanding Institutional Diversity* (2005).

During this past spring, I asked Michael Cox to code research papers written by other scholars about the design principles. For his dissertation, Cox is studying self-organized irrigation systems in New Mexico (the acequias established by migrants from Spain using many of the designs that they had developed in their home country), so this was also relevant for his own work. Cox has now coded 33 articles where other scholars have evaluated whether the design principles hold up in their studies or not. (These articles are listed in the references preceded by an asterisk.) Each of the articles has looked at one or more resources in some depth and examined which design principles were relevant and whether they are positively related to the outcomes, negatively related, or did not make much difference.

In Figure 1, the distribution across all cases coded in regard to their summary evaluation is presented. To my relief, it does appear that 73 percent of the cases that Cox has coded are either moderately or highly supportive of the usefulness of the design principles. Table 2 presents the distribution of cases across sectors and across design principles. In general, it looks like they are helpful for understanding why some common-property institutions are robust, and it seems that the design principles are themselves relatively robust (only 1 out of 33 studies strongly challenges them). We have identified further cases that could be coded, and several Ph.D. students at IU will be coding these using the coding forms as developed by Cox.

<<Insert Figure 1 and Table 2 here>>

Some General Concerns

While many of the articles are quite supportive, there are both general and specific concerns raised that I will try to summarize here. One has to do with my reliance on a modified "rational choice approach." Several publications, including Cleaver (2000), Steins and Edwards (1999a, 1999b), and Young (2002), urge that the reliance on rational choice and collective action needs to be complemented (or perhaps substituted) by a constructivist approach. Steins, Röling, and Edwards (2000: 5), for example, criticize "the conventional scientific belief that reality can be divided into categories, and that its shaping mainly operates through cause-effect relations." I do have to confess that I think it is useful to analyze the diverse components of the world we try to analyze. Sometimes those components can be examined using additive models, but I have stressed the importance of understanding how *configurations* of causal conditions affect incentives, behaviors, and outcomes (see Ostrom 2005, 2007b).

Another general concern is that conditions that enhance the likelihood of crafting a working set of property rights are omitted. Scholars have urged the inclusion of such variables as: small size, homogeneous groups, and active leadership (Baland and Platteau 1996); dependence on a resource (Gibson 2001); market integration (Tucker 1999; Tucker, Randolph, and Castellanos 2007); external government policies (Rodriguez 2007); and cross-scale linkages (Berkes 2002; Young 2002). I agree that all of these and others are important variables and I use these and other variables in related work to explain the factors affecting the emergence of new institutions (Ostrom 2001). These are among the variables that affect whether or not resource users will organize to solve the collective-action problem of self-organization in the first place. As such, they are causal variables of a process. The design principles, on the other hand, are an effort to understand why the results of this process are robust in some cases and fail in others.

Concerns Regarding Specific Principles

Clearly defined boundaries

Some scholars suggest that this principle be divided into two parts—one focusing on the boundaries of those authorized to use a common-pool resource and the other related to the boundaries of the resource itself (Agrawal 2002). Specifying these as two principles may help in regard to another concern related to the rigidness of the boundary of a resource. Cleaver (2000) and Turner (1999) suggest that the boundaries of the resource can be "fuzzier" than the boundaries of who is authorized to use. When two user groups work side by side, they may have back-up arrangements that enable them to utilize each other's resource under commonly understood conditions.

One confusion about boundary rules is related to the difference between a *careful* definition of the boundaries of a resource (and potential of other related resources) and those boundaries being rigid and unchanging. For many pastoral resources, the boundaries of the physical resource may change depending upon the season and recent patterns of rainfall. Most pastoral peoples have several boundaries of their resources. One boundary relates to where they live most of the year. A second boundary relates to where they can pasture animals during normal seasons. A third or fourth boundary frequently exists for back-up regions that may be available to a well-defined group in seasons when their "home" territory is facing dire scarcity.

When the rainfall is abundant, there are very few questions about where one would pasture one's animals. If the rainfall for that local area has been scarce, there may be areas that are facing more adequate rainfall and forage availability. Most pastoral peoples have secondary and tertiary rights to pasture animals in the other regions depending on season (Agrawal 1999). Quinn et al. (2007: 105–106) describe the problem as now compounded by the central designation of village boundaries:

> Physical boundaries on resources in Africa are often not clearly defined and there are two important facts as to why this is the case. The nature of semi-arid regions means that resource availability varies both spatially and temporality (Cousins, 2000). . . . Imposed over this ecological variability in resource availability are the socio-political boundaries created by culture and political administration. For example, the political administration units created by villagisation in Tanzania do not necessarily relate to the underlying ecological boundaries. The tension between political and ecological boundaries creates a situation where the boundaries on resource users are often 'fuzzy' as resource users are drawn from a wider community than just one village, and different social and ethnic groups use overlapping parts of the same resource.

Thus, as we move to dividing the first principle into two parts, it will also be important to clarify what is meant by "clear" boundaries. Even when scholars have used "fuzzy set theory" to define boundaries, the boundaries of each of the resources in a set of resources are relatively clearly defined. And, for large pastoral or forest areas, it is not reasonable to put up fences to clearly demark all boundaries, but most such resources in the field do use some kind of marker stone or plant species to mark the boundaries on the various paths used frequently.

Niamir-Fuller (1998) focuses extensively on this first principle from her own research experience on pastoral peoples in Africa. She also describes the boundaries among different user groups as fuzzy and containing overlapping zones that "are jointly managed by the neighboring tribes" and buffer zones that "often did not come under strict management by any group, but access to them was negotiated between parties concerned on an ad hoc basis" (1998: 269). Niamir-Fuller points out that it is very important to understand that

> although different people can use the same communal land, users are subject to regulations that determine their *priority* of use. Any group has priority of use within the boundary of its 'home territory,' but this land can also be used by others seasonally or infrequently. (1998: 272–73)

Morrow and Hull (1996) pointed out that many donor projects formally met the first design principle. Formal congruence with the first principle is not enough, however, to enable appropriators to defend their borders from free-riders. Morrow and Hull (1996: 1643) suggested a rephrasing for the first design principle to be: "The resource itself and the users of the resources are clearly defined, and the appropriators are able to effectively defend the resource from outsiders." Given our own findings about the importance of defending boundaries, this rephrasing is a positive step forward (Hayes and Ostrom 2005; Gibson, Williams, and Ostrom 2005).

Congruence between appropriation and provision and local conditions

This principle should probably also be divided into two or three sub-types—one related to the congruence with the local ecology, a second related to the congruence between the amount that a user is authorized to harvest and their responsibilities for contributing labor or other resources. Some scholars have also identified "local conditions" as involving the predominant culture, ideology, customs, and livelihood strategies (Gautam and Shivakoti 2005; Hallum 2008; Morrow and Hull 1996; Young 2002). Morrow and Hull (1996: 1643) restate it as: "Appropriation and provision rules are congruent with the resource and with the cultural norms and social and economic patterns of interaction of the appropriators. The pace and scale of the institution are congruent with traditional decision-making processes." Thus, I think that when doing a revision, this principle may need to have three subparts specifically dealing with congruence with the local ecology, congruence with the local culture, and congruence between benefits and costs.

Collective-choice arrangements

This principle has been discussed rather extensively in the common-property literature. Platteau (2003, 2004), for example, has indicated a concern that the users of locally controlled resources do not always have the opportunity to make their own rules. Some local resources are dominated by an elite who decide to receive most of the benefits and pay few of the costs. Where this happens, the collective-choice arrangements are not consistent with design principle 3.

Several authors did identify collective-choice arrangements and related principles as helping to explain outcomes achieved in different locations. Gautum and Shivakoti (2005), for example, examine the relevance of collective-choice arrangements and other design principles for understanding the difference in outcomes for two forest systems located in one ecological zone of Nepal serving users with similar socioeconomic attributes. In Dhulikhel, the forest is legally a national government forest and formally administered by a local District Forest Office. Little consensus exists among the users of the Dhulikhel forest regarding harvesting practices, and no mechanisms exist for the users to express their voice about the rules that should be used. In Jyalachitti, the forest was handed over to a formally established Forest User Group (FUG) in 1992. Since then, the FUG has developed its own rules, based on local customs, livelihood strategies, and the socioeconomic context. The rules are designed to enhance the regrowth of the Jyalachitti Forest, which was severely degraded in the 1960s when it was still a national forest. Gautum and Shivakoti report considerable regrowth in the Jyalachitti Forest, but that the conditions are worsening in the Dhulikhel Forest. The two forests also differ in regard to graduated sanctions and the extent of conflict-resolution mechanisms that together with having their own collective-choice arrangements has enabled the users of Jyalachitti Forest to achieve considerable improvement as contrasted to the Dhulikhel Forest.

Monitoring and graduated sanctions

In some of the cases, there was a little confusion between the process of monitoring itself and that of sanctioning. Scholars, such as Wilson (2007), also point out the importance of environmental monitoring in complex ecological systems as well as monitoring the behavior of

other users. Most of the studies coded this spring agreed with the importance of monitoring and graduated sanctions. Gautam and Shivakoti (2005: 169) recommended an addition to this principle that "there is no external pressure, which can effectively undermine local monitoring efforts" since they observed external processes that undermined effective monitoring and sanctioning in one of the forests they studied. Sarker and Itoh (2001) examined a set of long-enduring Japanese irrigation systems and found while there were no "official" rules establishing monitoring arrangements and graduated sanctions, these principles implicitly characterized most of the irrigation systems they studied.

In the Guatemalan community that Hallum (2008) analyzed, she found that the users of the resource monitored compliance with harvesting rules using the maps and schedules they have developed as they themselves used the forest. She pointed out that "in a close-knit rural community, it is very difficult for anyone to 'get away with' infractions" (2008: 17). If rules were broken, the sanctions tended to range from extra work assignments (in the community tree nursery or transplanting) or if the infractions were more serious, a reduction in access for obtaining firewood. If even more serious rules were broken, a special meeting might be called at the local church and the church bell rung to call attendance and attention.

Trawick (2001) analyzes a community irrigation system in Peru where the farmers have developed a contiguous pattern for irrigating a section of the system at a time before moving to other sections of the system. This system is effective at conserving water, but it also makes irrigation a public affair and monitoring much easier.

> Since everyone knows the rules that govern distribution, and thus the exact order in which they are supposed to receive water, and because the owners of adjoining parcels tend to irrigate on the same day, people are normally putting their fields in order, or simply waiting and watching, while their neighbors finish their turns. This means that monitoring, an essential function in any irrigation system, is pervasive and routine, spread out among users throughout the system, rather than a special task put entirely in the hands of the water distributor. The vigilance helps the distributors in ensuring that traditional procedures are followed, and it has the vital effect of providing controls upon theft, favoritism on the part of water officials, and other forms of corruption. (2001: 15)

One of my own vivid recollections from doing fieldwork in the Middle Hills of Nepal during the 1990s was seeing an enclosed field with a domesticated cow in the center of a village. In response to my question as to what was happening here, my Nepali colleagues indicated that the enclosure was a kind of "cow jail." When three adult members of the local farmer-managed irrigation system agreed that a member had not followed water harvesting or maintenance rules after receiving a verbal warning, they were authorized to bring a cow from the errant farmer's fields to the village area. In an agricultural village, everyone knows who owns a cow. Thus, while the cow was grazing in the center of the village producing milk for village council to distribute, all of the farmer's neighbors were learning about the farmer's nonperformance. Once the farmer had paid a modest fee for breaking the rules, the cow would be returned, so this second-stage sanction was not severe in the long run. Needless to say, however, most members of the irrigation system preferred to follow the rules rather than being embarrassed by this form of a graduated sanction.

Conflict-resolution mechanisms

The need for relatively low-cost, speedy, and effective conflict-resolution mechanisms had general support from the authors of the 33 studies. Gautam and Shivakoti (2005: 165) describe the provisions for conflict resolution in Jyalachitti—their successful case:

> The forest users' committee usually resolves smaller internal conflict, particularly related to the harvest and distribution of forest products. More complicated conflict internal to the FUG are resolved in FUG assemblies, sometimes with facilitation by local forestry staff. The FUG seeks support from the DFO for resolving conflicts arising from external factors. Being a semiautonomous entity, the FUG has the right to go to court for more serious conflicts but that has not happened.

The problem of conflict resolution in their second, and less successful, case is more complicated given the substantial differences in views of how the forest should be managed and that "the traditional mechanisms for dealing with internal conflicts that worked for centuries have eroded in recent years due to strong political divisions among the users" (2005: 165). They concluded that the "institutions governing the Dhulikhel forest system have also failed to provide low-cost, local arenas to resolve conflict" (2005: 165).

Minimal recognition of the rights to organize

Considerable evidence exists in the case studies where violations of this principle have been associated with less successful community-based resource management regimes. Sometimes NGOs that are created to "help" local groups as well as government agencies do overlook the authority of locals. Morrow and Hull (1996) suggest the following wording: "The rights of appropriators to devise their own institutions are not challenged by other authorities, internal or external, that have the ability to undermine the institutions." Gautam and Shivakoti (2005) make a similar recommendation.

Nested enterprises

Scholars focusing on pastoral and irrigation systems do stress the importance of smaller common-property systems being nested in larger and still larger ones given the high probability of these having cross-scale physical relationships (Niamir-Fuller 1998; Lane and Scoones 1993). Marshall (2008) describes the challenge of applying this principle in designing more effective community-based environmental governance systems in Australia while agreeing with its importance. He urges that the "principle of subsidiarity" is helpful in understanding and applying the concept of nesting (see also McKean 2002). This principle implies "that any particular task should be decentralized to the lowest level of governance with the capacity to conduct it satisfactorily" (Marshall 2008: 80).

Armitage (2008) relates the principle of nested enterprises to the concept of multilevel systems that is an essential attribute of natural systems analyzed by ecologists related to their resilience. He provides an overview of diverse experiences with linking governance and ecology across scales related to particular resource systems in Cambodia, Canada, India, Indonesia, and

Sweden (2008: 12–13). As others have done (including myself), Armitage warns against using design principles primarily like a recipe that can be easily followed in a top-down design process. He points out that:

> Issues of power and control, the social construction of problems, knowledge valuation and the positioning of different groups suggest that adaptive, multi-level governance in specific places and at specific times is dependent on variables and events that require thoughtful deconstruction. . . . Deliberative processes which encourage reflection, observation and opportunities for communication and persuasion among social actors where uncertainties are high (see Stern 2005) will be important in helping to articulate the full range of principles, values, models and assumptions. (2008: 25–26)

Thus, the nesting principle is shown to be important but without providing a simple formula that can be applied in a routine manner. Authors have stressed the importance of this principle and the multiple ways that it has been interpreted and applied in the field.

Where to From Here?

It appears that there are some advantages in rephrasing and expanding some of the design principles as discussed above. It is a relief to me that scholars have looked critically at their relevance and generally do agree that the design principles are capturing some of the important underlying elements in the wide diversity of specific institutional arrangements that have been designed and implemented by groups who have sustainable used their resources over time. I do plan on developing a revised set of design principles during the coming year after the other articles waiting to be coded have been analyzed and entered into the database. I think the major thrust of the revisions, however, will be to clarify them and to add further related attributes to them.

Another task will be to address the question of whether meeting all of the design principles is a necessary—or a necessary and sufficient—condition for robust and sustainable resources and a long lived institution. Given the complexity of the resources that are included in the broad definition of common-pool resources, I doubt that any list of design principles could be shown to be both necessary AND sufficient conditions for robustness. My own view has been that when a group designs a property-rights system that meets most of the design principles, that they have increased the probability of its surviving many disturbances over time and being robust. Further, if none of the design principles are present, I am willing to predict relatively rapid failure—as many of the empirical studies have shown.

Using the Design Principles in Practice

One concern that does come across in reading the papers that have assessed the usefulness of the design principles is that some scholars criticize their use as "blueprints." I agree! There is a danger that project planners searching for the "right" design will try to build a one-size-fits-all project based on the design principles (Campbell et al. 2006). This goes entirely against the theoretical argument presented in 1990. It is important to match the rules of a system to the underlying biophysical world and type of human community involved. The question is

often raised, however, how can the design principles be used in practice in addition to their use in organizing continuing research?

My colleague Michael McGinnis has suggested that we can draw on the work of Herbert Simon (1972, 1981, 1995, 1999), who has stressed the complexity of designing humanly engineered systems whether they be computers, road networks, or institutional arrangements. My earlier work related to the impossibility of doing a *complete* analysis of a complex, adaptive system was strongly influenced by the work of Simon. Simon points out that where one begins a search to improve the importance of a complex system, however, can make a substantial difference in the quality and speed of the search process. Thus, in thinking about the practical implications of the design principles, one approach is to think of them as the starting point for conducting a search of appropriate means of solving problems. One can then translate them into a series of questions that could be asked when thinking about improving the robustness of a common-pool resource system. In Ostrom (2005: 270–71), I did propose a rough translation of the first six design principles as:

1. How can we better define the boundaries of this resource and of the individuals who are authorized to use it so as to ensure clarity in who is authorized to harvest and where harvesting is authorized?

2. How can we improve the relationship between the benefits received and the contributions to the necessary costs of sustaining this system?

3. How can we enhance the participation of those involved in making key decisions about this system?

4. Who is monitoring this system and do they face appropriate incentives given the challenge of monitoring?

5. What are the sanctions we are authorizing and can they be adjusted so that someone who makes an error or a small rule infraction is warned sufficiently so as to ensure longer-term compliance without having to impose unrealistic sanctions?

6. What local and regional mechanisms exist to resolve conflicts arising over the use of a resource?

Since the seventh and eighth principles relate to higher levels of governance, they could be translated as:

7. Are there functional and creative efforts by local appropriators to create effective stewardship mechanisms for local resources that should be recognized?

8. How do we create a multiple-layer, polycentric system that can be dynamic, adaptive, and effective over time?

Of course, these are not the *only* questions that local users and officials should ask in trying to implement an effective design process, but given the substantial evidence that they do characterize successful systems, they can be thought of as a good beginning. We all face a long list of questions to be pursued in our future work!

Notes

[1] Since many policy analysts have assumed that property rights have to be established by an external authority—"the" state—self-organized common-property systems are frequently "invisible" to them. They presume that unless they find legal documents creating a property system that it does not exist. As more conservation policies have been adopted in the last several decades, they have frequently imposed new centralized institutions on indigenous peoples leading in some cases to increased destruction of delicate ecosystems rather than increased protection of these.

[2] In a very large number of one-shot, public good experiments undertaken in diverse countries, however, subjects tend to contribute an average amount between 40 to 60 percent of the optimal level of contributions (Davis and Holt 1993: 325; Sally 1995).

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Table 1. Design Principles Derived from Studies of Long-Enduring Institutions for Governing Sustainable Resources

1. *Clearly Defined Boundaries*
   The boundaries of the resource system (e.g., irrigation system or fishery) and the individuals or households with rights to harvest resource units are clearly defined.

2. *Proportional Equivalence between Benefits and Costs*
   Rules specifying the amount of resource products that a user is allocated are related to local conditions and to rules requiring labor, materials, and/or money inputs.

3. *Collective-Choice Arrangements*
   Most individuals affected by harvesting and protection rules are included in the group who can modify these rules.

4. *Monitoring*
   Monitors, who actively audit biophysical conditions and user behavior, are at least partially accountable to the users and/or are the users themselves.

5. *Graduated Sanctions*
   Users who violate rules-in-use are likely to receive graduated sanctions (depending on the seriousness and context of the offense) from other users, from officials accountable to these users, or from both.

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

7. *Minimal Recognition of Rights to Organize*
   The rights of users to devise their own institutions are not challenged by external governmental authorities, and users have long-term tenure rights to the resource.

For resources that are parts of larger systems:

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

Source: Based on Ostrom (1990: 90).

Table 2. Evaluating the Design Principles

Sector	*Forestry*	*Pastoral Systems*	*Irrigation Systems*	*Inshore Fishery*	*Multiple Resource Sectors*	*Total*
Highly supportive	1		4	1	3	9
Moderately supportive	7	1	4		3	15
Neutral		1	2		1	4
Moderately negative	1	1		1	1	4
Strongly negative					1	1
Total	9	3	10	2	9	33

Figure 1. Design Principles Evaluation