How Types of Goods and Property Rights Jointly Affect Collective Action

Elinor Ostrom

Journal of Theoretical Politics 2003; 15; 239
DOI: 10.1177/0951692803015003002

Journal of Theoretical Politics 15(3): 239–270
0951–6928[200307]15:3; 239–270; 033623

HOW TYPES OF GOODS AND PROPERTY RIGHTS JOINTLY AFFECT COLLECTIVE ACTION

Elinor Ostrom

ABSTRACT

The study of collective action has matured dramatically since Mancur Olson challenged scholars by positing a general theory in his pathbreaking book on *The Logic of Collective Action* (1965). Olson's theoretical predictions related to the incapacity of individuals, except under limited conditions, to solve on their own what are now known as 'collective action problems'. Olson argued that one characteristic of goods – that of exclusion – defined all public goods. In contemporary analysis, the problem of achieving exclusion of non-contributors has come instead to characterize all types of collective action problems. Multiple subtypes of collective action problems have been identified. One major class of collective action problems are referred to in contemporary literature as public goods. Another class are referred to as common-pool resources. Common-pool resources are characterized by difficulty of exclusion *and* subtractability of resource units and are threatened by overuse leading to congestion or even destruction of the resource. Such threats do not apply to public goods. Diverse production and allocation functions generate further important differences in behavior and outcomes. Scholars have also begun to recognize multiple types of property right bundles that distinguish among authorized entrants, users and claimants, proprietors and full owners. Empirical studies show that groups of individuals who possess at least the rights of proprietorship are able to govern and manage their systems more effectively than presumed in the earlier theoretical literature. The article ends with an analysis of the factors that may be conducive to the organization of a common-property regime as contrasted to a private-property regime.

KEY WORDS • collective action • common-pool resources • Mancur Olson • property rights • public goods

The study of collective action has developed extensively during the past 40 years since the publication of Mancur Olson's *The Logic of Collective Action* in 1965. While Olson attempted to build a general theory based on a minimalist conception of the factors affecting collective action, scholars were motivated by Olson's work to delimit the core concepts, undertake further theoretical work and engage in empirical analysis. Olson thus opened up a rich field of theoretical and empirical work. The empirically supported theory that has evolved utilizes a richer conception of the type of goods involved in collective action and of the institutions that can be used to provide, produce and allocate these goods.

Samuelson versus Musgrave

Olson's initial classification of goods was affected by a debate between Paul Samuelson and Richard Musgrave over the classification of goods and the need for non-market institutions to provide one kind of 'public' good. Samuelson (1954) started the debate by using one attribute – jointness of consumption – to divide all goods into two classes: private consumption goods and public consumption goods. Samuelson assumed that private consumption goods could be divided and allocated to different consumers but that collective consumption goods are those that 'all enjoy in common in the sense that each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good' (Samuelson, 1954: 387). While market catallactics would allow rational egoists to pursue narrow self-interest and yet produce socially optimal provision of private consumption goods, Samuelson argued that decentralized spontaneous solutions could not work to provide an optimal level of collective consumption goods. In 1959, Richard Musgrave argued that a different attribute of goods – whether or not someone can be excluded from benefiting once the good is produced – is more important than jointness of supply. Musgrave then asserted that the exclusion principle can be used by itself to divide the world into private and public goods. The classification debate was associated with a major policy concern over the role of government in allocating resources.

Both Samuelson and Musgrave were interested in the same question. Each posited a single criterion that would enable them to predict when markets would perform optimally and when markets would fail. The difference in their approach is illustrated in Figure 1. Samuelson uses his classification to argue that all of the left-hand column and none of the right-hand column include goods that can be effectively allocated through market mechanisms. Musgrave uses his classification to argue that all of the top row and none of the bottom row include goods that are best allocated through the market.

Olson explicitly adopted Musgrave's definition. Using this one-dimensional criterion, Olson then tried to establish a *general theory* for all goods meeting Musgrave's definition. It was a grand vision but overly ambitious. Multiple scholars have shown that several of his propositions do not hold for all goods meeting the Musgrave definition even though these same propositions do hold for a subset of goods for which exclusion is problematic (Chamberlin, 1974; Ostrom and Ostrom, 1977; Hardin, 1982; Dougherty,

	Samuelson's Classification	
Musgrave's Classification	One person's consumption subtracts from total available to others	One person's consumption does not subtract from total available to others
Exclusion is Feasible	Cell A	Cell B
Exclusion is Not Feasible	Cell C	Cell D

Figure 1. Samuelson's and Musgrave's Classification of Goods

2002). Obviously, Olson shared both Samuelson's and Musgrave's hope of developing a general theory.

Multiple Types of Collective Action Problems

Exclusion as the Key Attribute of all Collective Action Problems

Olson had a profound insight when he adopted Musgrave's criterion as the defining attribute for collective action problems. The name he used to characterize these problems – public goods – has appropriately come to be used for a subset of collective action problems rather than the universal set. Public goods are those collective action problems identified as Cell D of Figure 1 where consumption by one person does not reduce the amount available to others. Cell C has come to be known as representing a set of collective action problems that are called common-pool resources (Ostrom and Ostrom, 1977; Ostrom et al., 1994).

While Musgrave and Olson tended to assume that exclusion was impossible for a subset of all goods, more recent theoretical work has understood that the capacity to exclude potential beneficiaries depends both on the technology of physical exclusion devices, such as barbed wire fences and electronic sensing devices, as well as the existence and enforcement of various bundles of property rights (Cornes and Sandler, 1994; Ostrom et al., 1994). Thus, as discussed later, many people facing collective action problems in the field have changed the structure of the problem they face by building walls (the walled cities of medieval times were, after all, a way of excluding outsiders from the defenses of the city) or creating property rights (inshore fishers have long used customary law to enforce locally devised rules as to who was allowed to fish) (Acheson and Brewer, 2003; Hanna, 2003).

Consequently, all collective action problems share the problem that excluding non-contributors to a collective benefit is non-trivial. Collective action problems differ in regard to how costly or difficult it is to devise physical or institutional means to exclude others. Some of these differences stem from the biophysical world itself. It will always be more difficult to exclude users from an ocean or other global commons than from a farmer's pond (Sandler, 1997, 1998).

The next conundrum to be resolved is whether one theory can explain all patterns and outcomes for collective action problems, as Olson hoped, or whether a family of closely related theories is needed. After more than 30 years of unsuccessful efforts to build one explanatory theory for all collective action problems and multiple insightful critiques of these efforts, I will argue strongly that further efforts to build a single general theory are counterproductive.

Subtractability

Olson actually started the task of building subtheories. He himself classified what he called public goods into exclusive and inclusive public goods and made radically different predictions for the two subclasses. His 'exclusive public good' is Cell C. Here, Olson expected groups to try to keep their size as small as possible, to try to get 100 percent participation since 'even one non-participant can usually take all of the benefits brought about by the action of [others] for himself' (Olson, 1965: 41). In the field, groups using a common-pool resource who have found ways to reduce over-appropriation frequently try to limit members, as Olson predicted, through clear and enforced boundary rules specifying exactly who can use the resource (Stern et al., 2002).

Olson's inclusive groups, in contrast, will try to increase members. The more members there are in an inclusive group, the more individuals there will be who will share the costs of providing a good to all beneficiaries. In this setting, increasing the number of participants frequently brings additional resources that could be drawn on to provide a benefit that will be jointly enjoyed by all. It is because of the additional resources available in a larger group and the non-subtractability characteristic of public goods that Marwell and Oliver (1993: 45) conclude that when 'a good has pure jointness of supply, group size has a *positive* effect on the probability that it will be provided'. For example, the level of resources provided to support public radio is greater when a larger population can be called upon than for a small one. Olson also predicts that bargaining and strategic interactions will be less intense in an inclusive group than in an exclusive one.

Not all of the differences predicted by Olson have been tested but laboratory experiments provide clear evidence that common-pool resources and public goods are not only theoretically different types of goods but behavior in situations related to provision of one or the other type of good is substantially different (Ostrom et al., 1994). In a public good setting, noncooperative actions by one individual do not make a dramatic difference for others.

In finitely repeated, public goods experiments, the typical pattern is for subjects on average to contribute about 50 percent of the optimal level in the first round and then follow a pulsing decay pattern downward toward but never reaching the symmetric Nash equilibrium in the last rounds. In common-pool-resource problems, however, the typical pattern is just the opposite. In a common-pool-resource experiment, one person's aggressive withdrawals can generate very high costs for everyone else. In the initial rounds, subjects do much *worse* than Nash and then pulse upward toward the symmetric Nash equilibrium from below.

In addition to differences among collective action problems in regard to whether consumption is subtractive or not, many other characteristics affect the type of problems that people face in the field. In regard to common-pool resources, for example, Schlager et al. (1994) identify whether the products to be appropriated are mobile like fish or stationary like trees. Such attributes affect the costs of learning about the yield of a resource. Similarly, whether there is storage in the system affects the predictability of resource unit availability. When conducting field research, these attributes have strong impacts on the likelihood of successful collective action and the form that collective action takes (see Blomquist, 1992; Tang, 1992; Schlager, 1994; Lam, 1998). Instead of trying to identify the myriad of specific factors that are potentially important in the context of any well-designed fieldwork, however, I will discuss two abstract forms of representing some of these important differences – the type of production and appropriation functions that characterize a particular problem. In a later section, I will focus on how further attributes of a common-pool resource may affect the feasibility of diverse types of property regimes.

Production Functions

It is well understood that the production functions for producing private goods take on many shapes and forms. The same is true of public goods and common-pool resources. The most frequently assumed production function is linear. In a linear public goods game, there are N identical players who are each assigned an endowment, E. Each player, I, must then decide between keeping the endowment or contributing some part of the endowment xi_i to the production of a public good, G. A production function that determines the total amount of the public good, TG, is:

$$TG = P(Ex_i) \quad (1)$$

In the linear public good game, P signifies the marginal production externality created by contribution to the public good (Isaac and Walker, 1988).

If P is 0.25, for example, each person who contributes \$1.00 generates a public good of \$0.25 for everyone in the game. If four people contribute \$1.00 each, the total return just equals the total cost. In this instance, the minimum number of individuals contributing \$1.00, where benefits exceed costs, or k, would be five (see Frohlich and Oppenheimer [1996] for a clear analysis of when universal contributions is best for the group).

The production function that relates individual actions to group outcomes may take any of a wide diversity of forms as shown within a short time of the publication of Olson's book by Frohlich and Oppenheimer (1970), Schelling (1973) and Oppenheimer et al. (1975). The yield functions for common-pool resources have been represented since the seminal article of Scott Gordon (1954) as a quadratic function. Too many 'contributions', rather than too few, is the problem to overcome in a common-pool resource dilemma. As shown in Figure 2, Marwell and Oliver (1993) provide a synthesis of this work and focus on several other non-linear production functions (including general third-order functions (3c), concave (3e) and convex (3f)) that are characteristic of different types of production functions.

Marwell and Oliver analyzed a variety of monotonically increasing, non-linear production functions relating individual contributions and the total benefits produced and distinguish between production functions that are concave and those that are convex (decelerating and accelerating in their words). In the concave case, while every contribution increases the total benefits that a group receives, marginal returns decrease as more and more individuals contribute.[1] When contributions are made sequentially, the initial contributions have far more impact than later contributions. With a convex production function, initial contributions make small increments and later contributions yield progressively greater marginal benefits. Convex production functions 'are characterized by *positive interdependence*: each contribution makes the next one more worthwhile and, thus, more likely' (Marwell and Oliver, 1993: 63).

Settings where mass actions are needed in order to gain a positive response involve convex functions.[2] Their theoretical predictions concerning the success of collective action depend sensitively on the particular shape of

1. The example they use to illustrate such a production function is calling about a pothole in a neighborhood where a city administration is sensitive to citizen support (Marwell and Oliver, 1993: 62). The first call brings the pothole to the attention of city officials and puts it on the list of things to be repaired (raising the probability of repair from zero to perhaps .4 or higher). The second call increases the probability of repair still further, but not as much as the first call. Later calls continue to increase the probability but with a smaller and smaller increment.

2. A strike involving only a few workers is unlikely to produce the level of benefits yielded by a strike involving a very large proportion of the workers of a firm or in an industry.

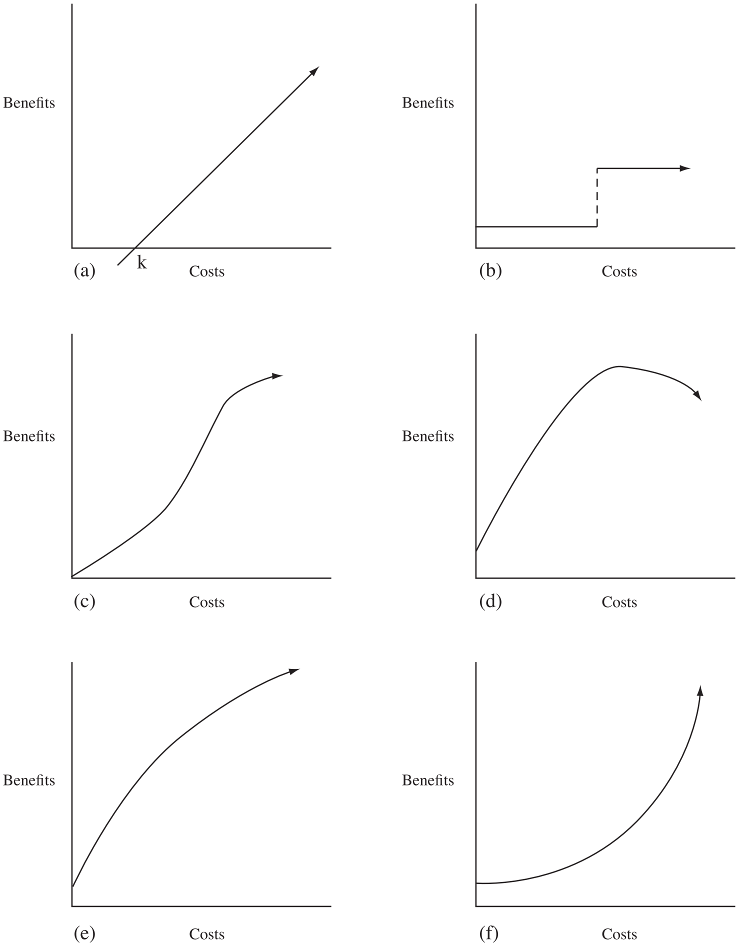

Figure 2. General Types of Production Function, (a) Linear, (b) Step Function, (c) General Third Order, (d) Quadratic, (e) Concave and (f) Convex.

Source: Modified from Marwell and Oliver (1993: 59).

the production function, on heterogeneity of wealth, on the sequence in which individuals contribute and on the information generated by each action. Thus, they depend on the type of production function to predict behavior and outcomes as well as other variables. To predict when these types of goods will be produced, one needs to analyze how a configuration of variables operates together – or how the effect of one set of variables depends upon other variables.

Step-level functions (3b) have also been of considerable interest to scholars of collective action[3] and demonstrate how a subtle difference in the production function of a collective good can make an immense difference in behavior and outcomes. In a step-level production function, actions by up to k participants make no difference in the outcomes obtained but actions by k or more participants discontinuously shift the benefit upward.[4] Russell Hardin (1976) was among the first to argue that when the shape of the production function for a public good was a step function, solving social dilemmas could be facilitated since no good would be provided if participants did not gain sufficient inputs to equal or exceed the provision point (k). Until the benefit is actually produced, it is impossible to 'free ride' on the contribution of others. In these settings, individuals may assume that their participation is critical to the provision of the good. This type of production function creates an 'assurance problem' rather than a strict social dilemma. For those who perceive their contribution as critical, not contributing is no longer the unique Nash equilibrium.

In a series of public good experiments, John Orbell, Robin Dawes and colleagues used various institutional arrangements to create a discrete provision point or a step level function. All of these experiments had seven participants who were given a promissory note for $5.00 at the beginning of the experiment. Subjects were told that if a minimal contributing set (or k) – either three or five – contributed their promissory note, all subjects would receive $10.00 including those who had not contributed. With less than the required number of contributions, no good would be provided. In a series of baseline experiments, subjects were not allowed to communicate and were told only the size of the minimal contributing set needed to obtain the public good. The level of cooperation in these one-shot games without communication is much higher than the zero level predicted. The public good was provided in seven out of ten of the experiments where the minimal contributing set equaled three (50 percent of the individuals contributed) and in four out of ten of the experiments with a minimal contributing set of five (64 percent of the individuals contributed) (van de Kragt et al., 1983).

3. Step-level functions are, however, not strictly social dilemmas when there is complete information about the exact shape of the function. When individuals perceive themselves as critical to the achievement of a collective good, the game becomes a coordination game rather than a social dilemma.

4. Step functions characterize facilities such as bridges, tunnels and roads that have little value if not completed. Some scholars have argued that many public goods are characterized by provision points (Taylor and Ward, 1982; Hampton, 1987; Taylor, 1987).

Allocation Functions

In formal analyses of collective action, less attention has been paid to allocation functions since it is frequently assumed to be available to all in a group whether or not they have contributed. In any effort to understand multiple types of collective action problems it is also important to include analysis of the function that assigns individuals a share of the total benefits or the total costs. Thus, the utility to an individual is the result of the operation of a production function, P, as well as an allocation function, A.

$$U_i = U_i[(E - x_i) + A \cdot P(Ex_i)] \quad (2)$$

where U_i is the utility of the ith person, E is the individual endowment or assets and x_i is the amount contributed.

The allocation function can initially represent the 'natural' allocation in a base game without property rights. Or, to explain behavior in field settings, one needs to understand how property rights and other allocation rules affect the distribution of benefits and costs to participants.

In a non-divisible good, each person would receive TG. For universal public goods, such as peace and stability, each individual benefits in a similar manner without subtraction from the existence of these states of affairs. In a common-pool resource game, A can be operationalized as x_i/Ex_i or as a proportionate share of the total based on the rates of contribution levels. A host of allocation functions are actually found in field settings including allocation according to (1) the value of assets held (the function that Olson used); (2) seniority of claims; and (3) spatial or temporal formula. Sandler (1998) stresses that underlying aggregation 'technologies' vary in the degree to which they are supportive of collective action.

Allocation formulas can also make each person in a group, or a designated minimal contributing group, feel that their contribution is critical (van de Kragt et al., 1983). By agreeing that each person will contribute a set proportion of what is believed to be the total cost of obtaining a good, the individuals in such a minimal contributing set face a choice between not contributing and receiving nothing or contributing and receiving the benefit (assuming others in the minimal contributing set also contribute). The game has been transformed from a social dilemma into an assurance game.

For example, communication enabled participants in the one-shot provision-point public good game, described more fully earlier, to arrive at an allocation formula (van de Kragt et al., 1983). In all 12 communication experiments, subjects used the opportunity for discussion to decide exactly who would or would not be expected to contribute to the public good. Some groups used lotteries and others relied on simple volunteering. In one case, they encouraged those subjects, who had a higher need for the additional $5.00 associated with non-contribution, to identify themselves. In 10 of these 12 experiments, the discussion led to a decision designating the optimal number of participants to be contributors. In all 10 cases, those designated did contribute even though their decision was anonymous. In the other two experiments, the discussion led to the identification of a group of contributors larger than necessary. The authors attribute the high level of success in these communication experiments (as contrasted to moderate levels in their base of experiments described earlier) to the sense of criticalness that participants gained when a minimal contributing set was actually designated through their discussion period. Here the allocation formula made a substantial difference in the outcome achieved.

Marks and Croson (1998) examine alternative rebate rules in the provision of a step-level public good. They find that contributions to the provision of the good are significantly higher under a ‘utilization rebate’ rule than under two other rules examined. Using this rule, contributions that are made above those necessary to meet the provision point of the public good are devoted to provide more of a similar public good but one that has a continuous production function. If the original good were an infrastructure, for example, the additional funds could be used to plant trees around the infrastructure. In this setting, what one contributes to the provision of the step-level infrastructure can be allocated to the continuous ‘environmental’ public good. In their experiments, Marks and Croson (1998) find that contributions were significantly higher in those experiments with a utilization rebate rule than in those experiments where no rebate was made for over-contributions or where the rebate was re-distributed to contributors on a proportional basis. Using the latter two allocation functions, contributions were very close to the deficient Nash equilibrium for the game.

Common-pool Resources and Diverse Property Regimes

The key argument being made in this article is that attributes of the goods produced and allocated, as well as the rules used for their production and allocation, affect the diverse incentives that participants face. The first attribute that scholars should examine is whether excluding beneficiaries requires high costs or only low costs. If exclusion is costly, potential beneficiaries face a collective action problem. Second, one needs to determine whether consumption is subtractive or not. Potential beneficiaries whose consumption is subtractive face a common-pool resource type of collective action problem. Further distinctions are needed to get full theoretical leverage on how diverse property-rights regimes are likely to perform and be used (Aggarwal and Dupont, 1999).

Several confusions, besides those related to the core definitions of a public good and a common-pool resource, have led to misunderstandings in academic and policy debates. The term 'common-property resource', for example, is frequently used to describe the type of economic good with high exclusion costs and where one person's consumption subtracts from the total – or a 'common-pool resource'. Recognizing a class of goods that share these two attributes enables scholars to identify core theoretical problems. Using *property* in the term used to refer to a *type of good* reinforces the impression that goods sharing these attributes tend everywhere to be produced and allocated through the same property regime.

Common-pool resources may be owned by national, regional or local governments, by communal groups or by private individuals or corporations. When they are owned by no one or paradoxically by 'everyone', they are used as open access resources by whomever can gain access. The confusion between common property and open access is rampant.

Each of the broad types of property regimes has different sets of advantages and disadvantages but at times may rely upon similar operational rules regarding access and use of a resource (Feeny et al., 1990). Examples exist of both successful and unsuccessful efforts to govern and manage common-pool resources by governments, communal groups, cooperatives, voluntary associations and private individuals or firms (Bromley et al., 1992; Singh, 1994; Singh and Ballabh, 1996). Thus, common-pool resources are not automatically associated with common-property regimes – *or with any other particular type of property regime*.

A property right is an enforceable authority to undertake particular actions in a specific domain (Commons, 1968).[5] Property rights define actions that individuals can take in relation to other individuals regarding some 'thing'. If one individual has a right, someone else has a commensurate duty to observe that right. Schlager and Ostrom (1992) identify five property rights that are most relevant for the use of common-pool resources, including access, withdrawal, management, exclusion and alienation. These are defined as follows.

Access: the right to enter a defined physical area and enjoy non-subtractive benefits (e.g. hike, canoe, sit in the sun).

Withdrawal: the right to obtain resource units or products of a resource system (e.g. catch fish, divert water).

Management: the right to regulate internal use patterns and transform the resource by making improvements.

Exclusion: the right to determine who will have an access right, and how that right may be transferred.

5. This section draws on Ostrom and Schlager (1996).

Alienation: the right to sell or lease exclusion, management or withdrawal rights.

In much of the economics literature, private property is defined as equivalent to the right of alienation. Property-rights systems that do not contain the right of alienation are frequently considered to be ill defined. Further, they are presumed to lead to inefficiency since property-rights holders cannot trade their interest in an improved resource system for other goods or money nor can someone who has a more efficient use of a resource system purchase that system in whole or in part (Demsetz, 1967). Property-rights systems that include the right to alienation are to be most efficient because it is assumed that rights to their use will be transferred to those who will allocate them to their highest valued use. Larson and Bromley (1990) challenge this commonly held view and show that much more information must be known about the specific values of a large number of parameters before judgements can be made concerning the efficiency of a particular type of property right.

Instead of focusing on only one right, it is far more useful to define five classes of property-rights holders as shown in Table 1. In this view, individuals or collectivities may hold well-defined property rights that include or do not include all five of the rights defined earlier. This approach separates the question of whether a particular right is well defined from the question of the effect of having a particular set of rights. 'Authorized entrants' include most recreational users of national parks who purchase an operational right to enter and enjoy the natural beauty of the park but do not have a right to harvest forest products.

Those who have both entry and withdrawal use-right units are 'authorized users'. The presence or absence of constraints upon the timing, technology used, purpose of use and quantity of resource units harvested are determined by operational rules devised by those holding the collective-choice rights (or authority) of management and exclusion. The operational rights of entry and use may be finely divided into quite specific 'tenure niches' (Bruce, 1995) that vary by season, by use, by technology and by space. Tenure niches may overlap when one set of users owns the right to harvest fruits from trees, another set of users owns the right to the timber in these trees and the trees may be located on land owned by still others (Bruce et al., 1993). Operational rules may allow authorized users to transfer access and withdrawal rights either temporarily through a rental agreement or permanently when these rights are assigned or sold to others (see Adasiak [1979] for a description of the rights of authorized users of the Alaskan salmon and herring fisheries).

'Claimants' possess the operational rights of access and withdrawal plus a collective-choice right of managing a resource that includes decisions concerning the construction and maintenance of facilities and the authority to

Table 1. Bundles of Rights Associated with Positions

	Full owner	Proprietor	Authorized claimant	Authorized user	Authorized entrant
Access	X	X	X	X	X
Withdrawal	X	X	X	X	
Management	X	X	X		
Exclusion	X	X			
Alienation	X				

Source: Ostrom and Schlager (1996: 133).

devise limits on withdrawal rights. The net fishers of Jambudwip, India, for example, annually regulate the positioning of nets so as to avoid interference but do not have the right to determine who may fish along the coast (Raychaudhuri, 1980). Farmers on large-scale government-owned irrigation systems frequently devise rotation schemes for allocating water on a branch canal (Shivakoti and Ostrom, 2002). Local groups who obtain hunting rights assigned by a government agency frequently have rights as claimants (Gibson, 1999) as do fisheries assigned transferable quotes by a government agency (see Eythórsson, 2003).

'Proprietors' hold the same rights as claimants with the addition of the right to determine who may access and harvest from a resource. Most of the property systems that are called 'common-property' regimes involve participants who are proprietors and have four of the previously described rights but do not possess the right to sell their management and exclusion rights even though they most frequently have the right to bequeath it to members of their family (see Berkes, 1989; Bromley et al., 1992; Acheson and Brewer, 2003; Hanna, 2003).

Empirical studies have found that some proprietors have sufficient rights to make decisions that promote long-term investment and harvesting from a resource. Place and Hazell (1993) conducted surveys in Ghana, Kenya and Rwanda to ascertain if indigenous land-right systems were a constraint on agricultural productivity. They found that having the rights of a proprietor as contrasted to an owner in these settings did not affect investment decisions and productivity. Other studies conducted in Africa (Migot-Adholla et al., 1991; Bruce and Migot-Adholla, 1994) also found little difference in productivity, investment levels or access to credit. In densely settled regions, however, proprietorship over agricultural land may not be sufficient (Feder et al., 1988; Feder and Feeny, 1991). In a series of studies of inshore fisheries, self-organized irrigation systems, forest user groups and groundwater institutions, proprietors tended to develop strict boundary rules to exclude non-contributors; established authority rules to allocate withdrawal rights; devised methods for monitoring conformance; and used graduated sanctions against those who did not conform to these rules (Blomquist, 1992; Agrawal, 1994; Schlager, 1994; Tang, 1994; Lam, 1998; Ostrom et al., 2002).

'Full owners' possess the right of alienation – the right to transfer a good in any way the owner wishes that does not harm the physical attributes or uses of other owners – in addition to the bundle of rights held by a proprietor. An individual, a private corporation, a government or a communal group may possess full ownership rights to any kind of good including a common-pool resource (Dahl and Lindblom, 1963; Montias, 1976). The rights of full owners, however, are never absolute. Even private owners have responsibilities not to generate particular kinds of harms for others (Demsetz, 1967). Partial owners may possess the right of alienation to one or more of the other rights but not the full set.

What should be obvious by now is that the world of property rights is far more complex than simply government, private and common property. These terms better reflect the status and organization of the holder of a particular right than the bundle of property rights held. All of the rights described here can be held by single individuals or by collectivities. Some communal fishing systems grant their members all five of these rights, including the right of alienation (Miller, 1989). Members in these communal fishing systems have full ownership rights. Similarly, farmer-managed irrigation systems in Nepal, the Philippines and Spain have established transferable shares to the systems. Access, withdrawal, voting and maintenance responsibilities are allocated by the amount of shares owned (Siy, 1982; Maass and Anderson, 1986; Martin and Yoder, 1983a,b,c; Martin, 1986). However, some proposals to 'privatize' inshore fisheries through the device of an Individual Transferable Quota (ITQ), allocate transferable use rights to authorized fishers but do not allocate rights related to the management of the fisheries, the determination of who is a participant nor the transfer of management and exclusion rights (see, for example, Yandle and Dewees, 2003). Thus, proposals to establish ITQ systems, which are frequently referred to as forms of 'privatization', do not involve full ownership but rather a form of partial ownership (Rose, 2002; Tietenberg, 2002).

Attributes of Common-pool Resources Conducive to the Use of Communal Property Rights

Given the diversity of property-right systems that can be utilized, an important question is why do users of common-pool resources elect to use a communal property system or a private-property system? What are the attributes of common-pool resources that are conducive to communal proprietorship or communal ownership as contrasted to individual ownership? Groups of individuals are considered to share communal property rights when they have formed an organization that exercises at least the collective-choice rights of management and exclusion in relationship to some defined resource system and the resource units produced by that system. Communal groups most frequently establish some means of governing themselves in relationship to a resource (Ostrom, 1990). Where communal groups are full owners, members of the group have the further right to sell their access, use, exclusion and management rights to others, subject in many systems to approval by other members of the group. Some communal proprietorships are formally organized and recognized by legal authorities as having a corporate existence. Other communal proprietorships are less formally organized and may exercise *de facto* property rights that may or may not be supported by legal authorities if challenged by non-members (see Ghate, 2000). Obviously, such groups hold less well-defined bundles of property rights than those who are secure in their *de jure* rights even though the latter may not hold the complete set of property rights defined as full ownership. In other words, well-defined and secure property rights may not involve the right to alienation.

Even though all common-pool resources share the difficulty of devising methods to achieve exclusion and the subtractability of resource units, the variability of common-pool resources is immense in regard to other attributes that affect the incentives of resource users and the likelihood of achieving outcomes that approach optimality. Further, whether it is difficult or costly to develop physical or institutional means to exclude non-beneficiaries depends both on the availability and cost of technical and institutional solutions to the problem of exclusion and the relationship of the cost of these solutions to the expected benefits of achieving exclusion from a particular resource.

Let us start initially with a discussion of land as a resource system. Where population density is extremely low, land is abundant and land generates a rich diversity of plant and animal products without much husbandry, the expected costs of establishing and defending boundaries to a parcel of land of any size may be greater than the expected benefits of enclosure (Demsetz, 1967; Feeny, 1993). Settlers moving into a new terrain characterized by high risk due to danger from others, from a harsh environment or from lack of appropriate knowledge may decide to develop one large, common parcel prior to any divisions into smaller parcels (Ellickson, 1993). Once land becomes scarce, conflict over who has the rights to invest in improvements and reap the results of their efforts can lead individuals to want to enclose land through fencing or institutional means to protect their investments. Tradeoffs in costs need to be considered. The more land that is included within one enclosure, the lower the costs are of defending all the boundaries but the higher the costs are of regulating the use of the enclosed parcel.

The decision to enclose need not be taken in one step from an open-access terrain to a series of private plots owned exclusively by single families (Field, 1984, 1985, 1989; Ellickson, 1993). The benefits of enclosing land depend on the scale of productive activity involved. For some agricultural activities, considerable benefits may be associated with smaller parcels fully owned by a family enterprise. For other activities, the benefits of household plots may not be substantial. Moving all the way to private plots is an efficient move when the expected marginal returns from enclosing numerous plots exceed the expected marginal costs of defending a much more extended system of boundaries and the reduced transaction costs of making decisions about use patterns (Nugent and Sanchez, 1995).

In a classic study of the diversity of property-rights systems used for many centuries by Swiss peasants, Robert Netting (1976, 1981) observed that the same individuals fully divided their agricultural land into separate family-owned parcels but that grazing lands located on the Alpine hillsides were organized into communal property systems. In these mountain valleys, the *same* individuals used different property-rights systems side-by-side for multiple centuries. Each local community had considerable autonomy to change local rules, so there was no problem of someone else imposing an inefficient set of rules on them. Netting argued that attributes of the resource affected which property-rights systems were most likely for diverse purposes. Netting identified five attributes that he considered to be most conducive to the development of communal property rights:

1. low value of production per unit of area,
2. high variance in the availability of resource units on any one parcel,
3. low returns from intensification of investment,
4. substantial economies of scale by utilizing a large area and
5. substantial economies of scale in building infrastructures to utilize the large area.

Steep land where rainfall is scattered may not be suitable for most agricultural purposes but can be excellent land for pasture and forests if aggregated into sufficiently large parcels. By developing communal property rights to large parcels of such land, those who are members of the community are able to share environmental risks due to the unpredictability of rain-induced growth of grasses within any smaller region. Further, herding and processing of milk products is subject to substantial economies of scale. If individual families develop means to share these reduced costs, all can save substantially. Building the appropriate roads, retaining walls and processing facilities may also be done more economically if these efforts are shared.

While the Swiss peasants were able to devote these harsh lands to productive activities, they had to invest time and effort in the development of rules that would reduce the incentives to overgraze and would ensure that investments in shared infrastructure were maintained over time. In many Swiss villages, rights to common pasturage were distributed according to the number of cows that could be carried over the winter using hay supplies produced on the owners' private parcels. In all cases, the village determined who would be allowed to use, the specific access and withdrawal rights to be used, how investment and maintenance costs were to be shared and how the annual returns from common processing activities were to be shared. All of these systems included at least village proprietorship rights but some Swiss villages developed full ownership rights by incorporating and authorizing the buying and selling of shares (usually with the approval of the village). Netting's findings are strongly supported by studies of mountain villages in Japan, where thousands of rural villages have held communal property rights to extensive forests and grazing areas located in the steep mountainous regions located above their private agricultural plots (McKean, 1982, 1992). Similar systems have existed in Norway for centuries (Örebech, 1993; Sandberg, 1993, 2001).

The importance of sharing risk is stressed in other theoretical and empirical studies of communal proprietorships (Nugent and Sanchez, 1993; Antilla and Torp, 1996; Bardhan and Dayton-Johnson, 2002). Unpredictability and risk are increased in systems where resource units are mobile and where storage facilities, such as dams, do not exist (Schlager et al., 1994). Institutional facilities for sharing risk, such as formal insurance systems or institutionalized mechanisms for reciprocal obligations in times of plenty, also affect the kinds of property-rights systems that individuals can devise. When no physical or institutional mechanisms exist for sharing risk, communal property arrangements may enable individuals to adopt productive activities not feasible under individual property rights. Empirical studies have shown that the variance in the productivity of land over space – due largely to the variance in rainfall from year to year – is strongly associated with the size of communally held parcels allocated to grazing in the Sudan (Nugent and Sanchez, 1995). Ellickson (1993) compares the types of environmental and personal security risks faced by new settlers in New England, in Bermuda and in Utah to explain the variance in the speed of converting jointly held land to individually held land in each of these settlements.

A consistent finding across many studies of communal property-rights systems is that these systems do not exist in isolation and are usually used in conjunction with individual ownership. In most irrigation systems that are built and managed by the farmers themselves, for example, each farmer owns his or her own plot(s) while participating as a joint proprietor or owner in a communally organized irrigation system (Coward, 1980; Sengupta, 1991, 1993; Tang, 1992; Wade, 1992; Vincent, 1995). Water is allocated to individual participants using a variety of individually tailored rules but those irrigation systems that have survived for long periods of time tend to allocate water and responsibilities for joint costs using a similar metric – frequently the amount of land owned by a farmer (Ostrom, 1990, 1992). In other words, benefits are roughly proportional to the costs of investing and maintaining the system itself.

Further, formally recognized communal systems are usually nested into a series of governance units that complement the organizational skills and knowledge of those involved in making collective-choice decisions in smaller units (Johnson, 1972). Since the Middle Ages, most of the Alpine systems in both Switzerland and Italy have been nested in a series of self-governing communities that respectively governed villages, valleys and federations of valleys (Merlo, 1989). In modern times, cantonal authorities in Switzerland have assumed an added responsibility to make periodic, careful monitoring visits to each alp on a rotating basis and to provide professional assessments and recommendations to local villages, thereby greatly enhancing the quality of knowledge and information about the sustainability of these resources (Glaser, 1987).

Contrary to the expectation that communal property systems lacking the right to alienate ownership shares are markedly less efficient than property-rights systems involving full ownership, substantial evidence exists that many communal proprietorships effectively solve a wide diversity of local problems with relatively low transaction costs (Gaffney, 1992; Sandberg, 1993, 1996a,b; Hanna and Munasinghe, 1995a,b; Wilson, 1995; Kaul, 1996). Obtaining valid and reliable measures of outputs and costs for a large number of property-rights systems covering similar activities in matched environmental settings is extremely difficult (see discussion in Gibson et al., 2000). In regard to irrigation, a series of careful studies of the performance of communal proprietorship systems as contrasted to government-owned and managed systems, clearly demonstrates the higher productivity of the communal systems controlling for relevant variables (Tang, 1992; Benjamin et al., 1994; Ostrom, 1996; Lam, 1998). Schlager's (1994) studies of inshore fisheries demonstrate that fishers who have clearly defined proprietorship are able to solve difficult assignment problems and assign the use of space and technology so as to increase both the efficiency and equity of their systems. Wilson's (1995) studies also demonstrate that communal proprietorship systems are more efficient than frequently thought.

Performance of communal property-rights systems varies substantially, however, as does the performance of all property-rights systems. Some communal systems fail or limp along at the margin of effectiveness just as private firms fail or barely hang on to profitability over long periods of time. National governments and international donors have devoted considerable funds to encourage decentralized efforts with varying degrees of success (Agrawal and Ostrom, 2001).

In addition to the environmental variables discussed earlier that are conducive in the first place to the use of communal proprietorship or ownership, the following variables related to the attributes of participants are conducive to their selection of norms, rules and property rights that enhance the performance of communal property-rights systems:

1. Accurate information about the condition of the resource and expected flow of benefits and costs are available at low cost to the participants (Gilles and Jamtgaard, 1981; Blomquist, 1992).
2. Participants share a common understanding about the potential benefits and risks associated with the continuance of the status quo as contrasted with changes in norms and rules that they could feasibly adopt (Ostrom, 1990; Sethi and Somanathan, 1996).
3. Participants share generalized norms of reciprocity and trust that can be used as initial social capital (Cordell and McKean, 1992; Anderson et al., 2003).
4. The group using the resource is relatively stable (Seabright, 1993).
5. Participants plan to live and work in the same area for a long time (and in some cases, expect their offspring to live there as well) and, thus, do not heavily discount the future (Grima and Berkes, 1989).
6. Participants use collective-choice rules that fall between the extremes of unanimity or control by a few (or even bare majority) and, thus, avoid high transaction or high deprivation costs (Ostrom, 1990).
7. Participants can develop relatively accurate and low-cost monitoring and sanctioning arrangements (Berkes, 1992).

Many of these variables are, in turn, affected by the type of larger regime in which users are embedded. If the larger regime recognizes the legitimacy of communal systems and is facilitative of local self-organization by providing accurate information about natural resource systems, providing arenas in which participants can engage in discovery and conflict-resolution processes, and providing mechanisms to back up local monitoring and sanctioning efforts, the probability of participants adapting more effective rules over time is higher than in regimes that ignore resource problems or presume that all decisions about governance and management need to be made by central authorities.

Two additional variables – the size of a group and its homogeneity – have been noted as conducive to the initial organization of communal resources and to their successful performance over time (Libecap, 1989a,b; Kanbur, 1991; Ostrom, 1992). As more research has been conducted, however, it is obvious that much more theoretical and empirical work is needed since both variables appear to have complex effects. Changing the size of a group, for example, always involves changing some of the other variables likely to affect the performance of a system. Increasing the size of a group is likely to be associated with at least the following changes: (1) an increase in the transaction costs of reaching agreements; (2) a reduction of the burden borne by each participant for meeting joint costs such as guarding a system and maintenance; and (3) an increase in the amount of assets held by the group that could be used in times of emergency (Cornes et al., 1986). Libecap (1995) found that it was particularly hard to get agreements to oil unitization with groups greater than four. Blomquist (1992), in contrast, documents processes conducted in the shadow of an equity court that involved up to 750 participants in agreeing to common rules to allocate rights to withdraw water from groundwater basins in southern California. The processes took a relatively long period of time but they have now also survived with little administrative costs for half a century. Agrawal (2000) has shown that communal forestry institutions in India that are moderate in size are more likely to reduce overharvesting than are smaller groups because they tend to utilize a higher level of guarding than smaller groups.

Group heterogeneity is also multifaceted in its basic causal processes and effects (Agrawal and Gibson, 2001; Bardhan and Dayton-Johnson, 2002). Groups can differ along many dimensions including their assets, their information, their valuation of final products, their production technologies, their time horizons, their exposure to risk (e.g. headenders versus tailenders on irrigation systems) as well as their cultural belief systems (Keohane and Ostrom, 1995; Schlager and Blomquist, 1998). Libecap's (1989b) research on inshore fisheries has shown that when fishers have distinctively different production technologies and skills, all potential rules for sharing withdrawal rights have substantial distributional consequences and are the source of conflict that may not easily be overcome. Libecap and Wiggins's (1984) studies of the pro-rationing of crude oil production reveal an interesting relationship between the levels and type of information available to participants and the likelihood of agreement at various stages in a bargaining process. In the early stages of negotiation, all oil producers share a relatively equal level of ignorance about the relative claims that each might be able to make under private-property arrangements. This is the most likely time for oil unitization agreements to be reached successfully. If agreement is not reached early, each participant gains asymmetric information about their own claims as more and more investments are made in private information. Agreements are unlikely at this stage. If producers then aggressively pump from a common oil pool, all tend to be harmed by the overproduction and are willing late in the process to recognize their joint interests. Libecap (1995) also shows a strong negative impact of heterogeneity in his study of marketing agreements among orange growers. The theoretical work of Mancur Olson

(1965) on privileged groups, however, predicts that when some participants have substantial assets and those interests are aligned with achieving an agreement, such groups are more likely to be organized. The empirical support for this proposition comes more from studies of global commons (Mitchell, 1995; Oye and Maxwell, 1995).

Attributes of Common-pool Resources Conducive to Use of Individual Property Rights

The advantage of individual ownership of strictly private goods – where the cost of exclusion is relatively low and one person's consumption is subtractive from what is available to others – is so well established that it does not merit attention here. Industrial and agricultural commodities clearly fit the definition of private goods. Individual rights to exclusion and to transferring control over these goods generate incentives that lead to higher levels of productivity than other forms of property arrangements.

It has frequently been assumed that land also is clearly always a private good and therefore best allocated using market mechanisms based on individual ownership rights. Agricultural land in densely settled regions is usually best allocated by a system of individual property rights. Gaining formal title to land, however, may or may not increase efficiency. Feder et al. (1988) conducted an important econometric study that showed that agricultural land in Thailand without a formal title was worth only one-half to two-thirds of land with a formal title. Further, increasing the security of private-property rights also led to an increased value of the crops produced (between one-tenth and one-fourth higher than those without secure title). More secure titling also provided better access to credit and led to greater investments in improved land productivity (see also Feder and Feeny, 1991).

Title insurance is one mechanism used to reduce the risk of challenges to ownership of land. Registering brands is still another technique used to increase the security of ownership over resource units in the form of cattle that may range freely over a large area until there is a communal effort to undertake a round-up. Gaining formal titles is, however, costly. In societies that do not yet have high population densities and where customary rights are still commonly understood and accepted, formal titling may be an expensive method of increasing the security of a title that is not associated with a sufficiently higher return to be worth the economic investment (see Migot-Adholla et al., 1991). In addition, it should now be clear that the cost of fencing land by physical and/or institutional means is non-trivial and that there are types of land and land uses that may be more efficiently governed by groups of individuals rather than single individuals.

A commonly recommended solution to problems associated with the governance and management of mobile resources units, such as water and fish, is their 'privatization' (Christy, 1973; Clark, 1980). What private ownership usually means in regard to mobile resource units, however, is ownership of the rights to withdraw a quantity of a resource unit and the right to alienate this harvesting right. Water rights are normally associated with the allocation of a particular quantity of water per unit of time or the allocation of a right to take water for a particular period of time or at a particular location. Fishing rights are similarly associated with quantity, time or location. These rights are typically 'withdrawal' rights that are tied to resource units and not to a resource system. In addition to the individual water rights that farmers hold in an irrigation system, they may also jointly own – and, therefore, govern and manage – the irrigation facilities themselves (Tang, 1992). In addition to the quotas or 'fishing units' that individual fishers may own, no one owns the fishing stock and governmental units may exercise various types of management rights in relationship to these stocks (Schlager, 1994). In groundwater basins that have been successfully litigated, individual pumpers own a defined quantity of water that they can produce, rent or sell but the groundwater basins themselves may be managed by a combination of general-purpose and special-purpose governmental units and private associations (Blomquist, 1992).

Implementing operational and efficient individual withdrawal rights to mobile resources is far more difficult in practice than demonstrating the economic efficiency of hypothetical systems (Yandle, 2001). Simply gaining valid and accurate measurements of 'sustainable yield' is a scientifically difficult task. In systems where resource units are stored naturally or by constructing facilities such as a dam, the availability of a defined quantity of the resource units can be ascertained with considerable accuracy, and buying, selling and leasing rights to known quantities is relatively easy to effectuate in practice. Many mobile resource systems do not have natural or constructed storage facilities and gaining accurate information about the stock and reproduction rates is costly and involves considerable uncertainty (Allen and McGlade, 1987; Wilson et al., 1991). Further, as Copes (1986) has clearly articulated, appropriators from such resources can engage in a wide diversity of evasive strategies that can destabilize the efforts of government agencies trying to manage these systems. Once such systems have allocated individual withdrawal rights, efforts to further regulate patterns of withdrawal may be difficult and involve expensive buy-back schemes (Örebech, 1982). Experience with these individual withdrawal-rights systems has varied greatly in practice (see Pinkerton, 1992, 1994; McCay, 1992; McCay et al. 1996; Wilson and Dickie, 1995; Yandle and Dewees, 2003). Further, efficiency is not the only criteria that should be taken into account when analyzing the effect of privatizing essential goods, such as water (Frohlich and Oppenheimer, 1995).

Exactly which attributes of both physical and social systems are most important to the success of individual withdrawal rights from common-pool resources is not as well established as the attributes of common-pool resource systems conducive to group proprietorship or ownership. On the physical side, gaining accurate measurements of the key variables (quantity, space, technology) that are to be involved in management efforts is essential. Resource systems that are naturally well bounded facilitate measurement as well as ease of observing appropriation behavior. Storage also facilitates measurement. Where resource units move over vast terrain, the cost of measurement is higher than when they are contained (e.g. it is easier to develop effective withdrawal-rights systems for lobsters than for whales).

Considerable recent research has also stressed the importance of involving participants in the design and implementation of individual withdrawal-rights systems (Yandle and Dewees, 2003). When participants do not look upon such rules as legitimate, effective and fair, the capacity to invent evasive strategies is substantial (Seabright, 1993; Wilson, 1995). The size of the group involved and the heterogeneity of participants also affect the costs of maintaining withdrawal-rights systems (Edwards, 1994). And, the very process of allocating quantitative and transferable rights to resource units may undo some of the common understandings and norms that allowed communal ownership systems to operate at lower day-to-day administrative costs.

Conclusion

Mancur Olson opened a vast territory for social scientists interested in the development of coherent bodies of theory that can be tested and improved by empirical research. Olson envisioned a general theory that would encompass findings for the entire territory of collective action. The territory turned out to be too vast and too heterogeneous for one general theory. This has not been a detriment, however, to further theoretical development and empirical testing except for those who eschew all complexity in social science theories.

Olson chose wisely when he stressed exclusion as the first theoretical attribute to consider. Whether it is costly or not to exclude beneficiaries from consuming a good, once it is provided, is indeed the most important theoretical distinction to be made among goods. It separates those where temptations to free ride exist and goods where individuals cannot free ride and still benefit. A second distinction – whether consumption of units by one person subtracts from the availability of benefits to others – is needed to separate public-good problems from common-pool resource problems. High levels of use of a common-pool resource can lead to its congestion, degradation and potentially to its destruction. High levels of consumption of a public good, such as knowledge or national defense, do not have the same adverse consequences. Given the dramatically opposite behavior and outcomes that occur in these two broad situations, this fundamental distinction among collective action problems must be made in efforts to provide a theoretical explanation.

The task of elucidating the theoretical family tree of collective action theories only starts with the distinction between public goods and common-pool resources. Next, one needs to examine how production and allocation formulae change the structure of incentives facing participants in these situations. Findings from experimental research support the overall argument that diverse production and allocation formulae strongly influence the behavior of participants and the outcomes achieved.

Another realm of theoretical development needed by scholars who want to understand and explain outcomes in collective action situations is the structure of property-right-regimes. Instead of distinguishing between 'well defined property rights' based only on whether users possess the right to alienate their ownership claims, five distinct basic bundles of rights are usefully distinguished. Any of the five may or may not be well defined. Incentives differ according to which combination of rights are possessed. Many existing regimes have managed resources sustainably for long periods of time without individuals possessing the rights of alienation. Instead, empirical studies show that groups of individuals who possess at least the rights of proprietorship are able to govern and manage their systems more effectively than presumed in the earlier theoretical literature.

Finally, attributes of common-pool resources conducive to common property and to individual private-property regimes are presented based on extensive field research and recent efforts to provide a theoretical synthesis. Instead of a general conclusion that one kind of property regime is best for all types of common-pool resources, a diversity of attributes affects the incentives of participants and the resulting performance.

Consequently, the resulting family of collective action theories has to include the rich interplay between the nature of the good, the property-right-regimes in place, the governance system used for making new rules and the resulting payoff structure. All of these attributes must be taken into account to generate empirically warrantable results. Olson's original formulation turns out to be one of the relevant special theories of this larger family of theories: a long-lasting and important contribution to the analysis of collective action problems.

Acknowledgement

This article was presented at the annual meeting of the Public Choice Society, San Diego, California, 22 –24 March 2002. The author is appreciative of the support from the National Science Foundation (Grant Number SBR-9521918). Comments made by Debbi Elms, Joe Oppenheimer, Piotr Swistak, and James Walker were very helpful.

REFERENCES

Acheson, James M. and Jennifer F. Brewer (2003) 'Changes in the Territorial System of the Maine Lobster Industry', in Nives Dolsak and Elinor Ostrom (eds) *The Commons in the New Millennium: Challenges and Adaptations*, pp. 37–59. Cambridge, MA: MIT Press.

Adasiak, Allen (1979) 'Alaska's Experience with Limited Entry', *Journal of the Fisheries Research Board of Canada* 36(7): 770–82.

Aggarwal, Vinod K. and Cédric Dupont (1999) 'Goods, Games, and Institutions', *International Political Science Review* 20(4): 393–409.

Agrawal, Arun (1994) 'Rules, Rule Making, and Rule Breaking: Examining the Fit between Rule Systems and Resource Use', in Elinor Ostrom, Roy Gardner and James Walker (eds) *Rules, Games, and Common-Pool Resources,* pp. 267–82. Ann Arbor: University of Michigan Press.

Agrawal, Arun (2000) 'Small Is Beautiful, But Is Larger Better? Forest-Management Institutions in the Kumaon Himalaya, India', in Clark Gibson, Margaret McKean and Elinor Ostrom (eds) *People and Forests: Communities, Institutions, and Governance*, pp. 57–85. Cambridge, MA: MIT Press.

Agrawal, Arun and Clark C. Gibson, eds (2001) *Communities and the Environment: Ethnicity, Gender, and the State in Community-Based Conservation*. New Brunswick, NJ: Rutgers University Press.

Agrawal, Arun and Elinor Ostrom (2001) 'Collective Action, Property Rights, and Decentralization in Resource Use in India and Nepal', *Politics & Society* 29(4): 485–514.

Allen, P.M. and J.M. McGlade (1987) 'Modelling Complex Human Systems: A Fisheries Example', *European Journal of Operational Research* 30: 147–67.

Anderson, C. Leigh, Laura A. Locker and Rachel A. Nugent (2003) 'A Framework for Analyzing the Physical-, Social-, and Human-Capital Effects of Microcredit on Common-Pool Resources', in Nives Dolsak and Elinor Ostrom (eds) *The Commons in the New Millennium: Challenges and Adaptations*, pp. 265–89. Cambridge, MA: MIT Press.

Antilla, Sten and Aivind Torp (1996) 'Environmental Adjustment and Private Economic Strategies in Reindeer Pastoralism: Combining Game Theory with Participatory Action Theory', Working paper. Mid-Sweden University.

Bardhan, Pranab and Jeff Dayton-Johnson (2002) 'Unequal Irrigators: Heterogeneity and Commons Management in Large-Scale Multivariate Research', in Elinor Ostrom, Thomas Dietz, Nives Dolsak, Paul C. Stern, Susan Stonich and Elke U. Weber (eds) *The Drama of the Commons*, pp. 87–112. Washington, D.C.: National Academy Press.

Benjamin, Paul, Wai Fung Lam, Elinor Ostrom and Ganesh Shivakoti (1994) *Institutions, Incentives, and Irrigation in Nepal,* Decentralization: Finance & Management Project Report. Burlington, VT: Associates in Rural Development.

Berkes, Fikret, ed. (1989) *Common Property Resources: Ecology and Community-Based Sustainable Development*. London: Belhaven.

Berkes, Fikret (1992) 'Success and Failure in Marine Coastal Fisheries of Turkey', in Daniel W. Bromley et al. (eds) *Making the Commons Work: Theory, Practice, and Policy,* pp. 161–82. San Francisco, CA: Institute for Contemporary Studies Press.

Blomquist, William (1992) *Dividing the Waters: Governing Groundwater in Southern California*. San Francisco, CA: Institute for Contemporary Studies Press.

Bromley, Daniel W., David Feeny, Margaret McKean, Pauline Peters, Jere Gilles, Ronald Oakerson, C. Ford Runge and James Thomson, eds (1992) *Making the Commons Work: Theory, Practice, and Policy*. San Francisco, CA: Institute for Contemporary Studies Press.

Bruce, John W. (1995) *Legal Bases for the Management of Land-Based Natural Resources as Common Property*. Rome, Italy: Forests, Trees and People Programme, Food and Agriculture Organization of the United Nations.

Bruce, John W., Louise Fortmann and Calvin Nhira (1993) 'Tenures in Transition, Tenures in Conflict: Examples from the Zimbabwe Social Forest', *Rural Sociology* 58(4): 626–42.

Bruce, John W. and Shem E. Migot-Adholla, eds (1994) *Searching for Land Tenure Security in Africa*. Dubuque, IA: Kendall/Hunt.

Chamberlin, J. (1974) 'Provision of Collective Goods as a Function of Group Size', *American Political Science Review* 68(2): 707–16.

Christy, Francis T. (1973) 'Fisherman Quotas: A Tentative Suggestion for Domestic Management'. Kingston: University of Rhode Island, Law of the Sea Institute.

Clark, Colin W. (1980) 'Restricted Access to Common-Property Fishery Resources: A Game Theoretic Analysis', in P.T. Lin (ed.) *Dynamic Optimization and Mathematical Economics*, pp. 117–32. New York: Plenum.

Commons, John R. (1968) *Legal Foundations of Capitalism*. Madison: University of Wisconsin Press.

Copes, Parzival (1986) 'A Critical Review of the Individual Quota as a Device in Fisheries Management', *Land Economics* 62(3): 278–91.

Cordell, John C. and Margaret A. McKean (1992) 'Sea Tenure in Bahia, Brazil', in Daniel W. Bromley et al. (eds) *Making the Commons Work: Theory, Practice, and Policy,* pp. 183–205. San Francisco, CA: Institute for Contemporary Studies Press.

Cornes, Richard, C. F. Mason and Todd Sandler (1986) 'The Commons and the Optimal Number of Firms', *Quarterly Journal of Economics* 101(Aug.): 641–46.

Cornes, Richard and Todd Sandler (1994) 'Are Public Goods Myths?', *Journal of Theoretical Politics* 6(3): 369–85.

Coward, E. Walter, Jr, ed. (1980) *Irrigation and Agricultural Development in Asia: Perspectives from the Social Sciences*. Ithaca, NY: Cornell University Press.

Dahl, Robert A. and Charles E. Lindblom (1963) *Politics, Economics and Welfare: Planning and Politico-Economic Systems Resolved into Basic Social Processes*. New York: Harper.

Demsetz, Harold (1967) 'Toward a Theory of Property Rights', *American Economic Review* 62: 347–59.

Dougherty, Keith L. (2002) 'The Theory of Collective Action before Mancur Olson', Paper presented at the 2002 Public Choice Meetings, 5 February, San Diego, CA.

Edwards, Steven F. (1994) 'Ownership of Renewable Ocean Resources', *Land Economics* 9: 253–73.

Ellickson, Robert C. (1993) 'Property in Land', *Yale Law Journal* 102: 1315–44.

Eythórsson, Einar (2003) 'Stakeholders, Courts, and Communities: Individual Transferable Quotas in Icelandic Fisheries, 1991–2001', in Nives Dolsak and Elinor Ostrom (eds) *The Commons in the New Millennium: Challenges and Adaptations*, pp. 129–67. Cambridge, MA: MIT Press.

Feder, Gershon and David Feeny (1991) 'Land Tenure and Property Rights: Theory and Implications for Development Policy', *World Bank Economic Review* 5(1): 135–53.

Feder, G., T. Onchan, Y. Chalamwong and C. Hangladoran (1988) *Land Policies and Form Productivity in Thailand*. Baltimore, MD: Johns Hopkins University Press.

Feeny, David (1993) 'The Demand for and the Supply of Institutional Arrangements', in Vincent Ostrom, David Feeny and Hartmut Picht (eds) *Rethinking Institutional Analysis and Development*, pp. 159–209. San Francisco, CA: Institute for Contemporary Studies Press.

Feeny, David, Fikret Berkes, Bonnie J. McCay and James M. Acheson (1990) 'The Tragedy of the Commons: Twenty-Two Years Later', *Human Ecology* 18(l): 1–19.

Field, Barry C. (1984) 'The Evolution of Individual Property Rights in Massachusetts Agriculture, 17th–19th Centuries', *Northeastern Journal of Agricultural and Resource Economics* 14: 97–109.

Field, Barry C. (1985) 'The Optimal Commons', *American Journal of Agricultural Economics* 67: 364–7.

Field, Barry C. (1989) 'The Evolution of Property Rights', *Kyklos* 42(3): 319–45.

Frohlich, Norman and Joe Oppenheimer (1970) 'I Get by with a Little Help from My Friends', *World Politics* XI (Oct.): 104–20.

Frohlich, Norman and Joe Oppenheimer (1995) 'Alienable Privatization Policies: The Choice Between Inefficiency and Injustice', in Ariel Dinar and Edna Loehman (eds) *Water Quantity/Quality Management and Conflict Resolution: Institutions, Processes, and Economic Analyses,* pp. 131–42. Westport, CT: Praeger.

Frohlich, Norman and Joe Oppenheimer (1996) 'When is Universal Contribution Best for the Group? Characterizing Optimality in the Prisoners' Dilemma Game', *Journal of Conflict Resolution* 40(3): 502–16.

Gaffney, Mason (1992) 'The Taxable Surplus in Water Resources', *Contemporary Policy Issues* 10: 74–82.

Ghate, Rucha (2000) 'The Role of Autonomy in Self-Organizing Processes: A Case Study of Local Forest Management in India', Working paper. Bloomington: Indiana University, Workshop in Political Theory and Policy Analysis.

Gibson, Clark (1999) *Politicians and Poachers: The Political Economy of Wildlife Policy in Africa*. Cambridge: Cambridge University Press.

Gibson, Clark C., Margaret A. McKean and Elinor Ostrom, eds (2000) *People and Forests. Communities, Institutions, and Governance*. Cambridge, MA: MIT Press.

Gilles, Jere L. and Keith Jamtgaard (1981) 'Overgrazing in Pastoral Areas: The Commons Reconsidered', *Sociologia Ruralis* 2: 335–58.

Glaser (Picht), Christine (1987) 'Common Property Regimes in Swiss Alpine Meadows', Paper presented at the Conference on Advances in Comparative Institutional Analysis, Inter-University Center of Postgraduate Studies, Dubrovnik, Yugoslavia, 19–23 October.

Gordon, H. Scott (1954) 'The Economic Theory of a Common-Property Resource: The Fishery', *Journal of Political Economy* 62: 124–42.

Grima, A.P. Limo and Fikret Berkes (1989) 'Natural Resources: Access, Rights to Use and Management', in Fikret Berkes (ed.) *Common Property Resources; Ecology and Community-Based Sustainable Development*, pp. 33–54. London: Belhaven.

Hampton, Jean (1987) 'Free Rider Problems in the Production of Public Goods', *Economics and Philosophy* 3: 245–73.

Hanna, Susan (2003) 'Transition in the American Fishing Commons: Management Problems and Institutional Design Challenges', in Nives Dolsak and Elinor Ostrom (eds) *The Commons in the New Millennium: Challenges and Adaptations*, pp. 61–76. Cambridge, MA: MIT Press.

Hanna, Susan and Mohan Munasinghe (1995a) 'An Introduction to Property Rights and the Environment', in Susan Hanna and Mohan Munasinghe (eds) *Property Rights and the Environment*. Stockholm and Washington, D.C.: The Beijer International Institute of Ecological Economics and The World Bank.

Hanna, Susan and Mohan Munasinghe, eds (1995b) *Property Rights in a Social and Ecological Context; Case Studies and Design Applications*. Stockholm and Washington, D.C.: The Beijer International Institute of Ecological Economics and The World Bank.

Hardin, Russell (1976) 'Group Provision of Goods', *Behavioral Science* 21: 101–6.

Hardin, Russell (1982) *Collective Action*. Baltimore, MD: Johns Hopkins University Press.

Isaac, R. Mark and James M. Walker (1988) 'Group Size Effects in Public Goods Provision: The Voluntary Contributions Mechanism', *Quarterly Journal of Economics* 103: 179–99.

Johnson, Omotunde E.G. (1972) 'Economic Analysis: The Legal Framework and Land Tenure Systems', *Journal of Law and Economics* 15(1): 259–76.

Kanbur, Ravi (1991) 'Heterogeneity, Distribution and Cooperation in Common Property Resource Management', Background paper. Washington, D.C.: The World Bank.

Kaul, Minoti Chakravarty (1996) *Common Lands and Customary Law: Institutional Change in North India over the Past Two Centuries*. Oxford: Oxford University Press.

Keohane, Robert O. and Elinor Ostrom, eds (1995) *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains*. London: Sage.

Lam, Wai Fung (1998) *Governing Irrigation Systems in Nepal: Institutions, Infrastructure, and Collective Action*. Oakland, CA: Institute for Contemporary Studies Press.

Larson, Bruce A. and Daniel W. Bromley (1990) 'Property Rights, Externalities, and Resource Degradation: Locating the Tragedy', *Journal of Development Economics* 33: 235–62.

Libecap, Gary D. (1989a) *Contracting for Property Rights*. New York: Cambridge University Press.

Libecap, Gary D. (1989b) 'Distributional Issues in Contracting for Property Rights', *Journal of Institutional and Theoretical Economics* 145: 6–24.

Libecap, Gary D. (1995) 'The Conditions for Successful Collective Action', in Robert O. Keohane and Elinor Ostrom (eds) *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains*, pp. 161–90. London: Sage.

Libecap, Gary D. and Steven N. Wiggins (1984) 'Contractual Responses to the Common Pool: Prorationing of Crude Oil Production', *American Economic Review* 74: 87–98.

Maass, Arthur and Raymond L. Anderson (1986) *And the Desert Shall Rejoice: Conflict, Growth, and Justice in Arid Environments*. Malabar, FL: R.E. Krieger.

Marks, Melanie and Rachel Croson (1998) 'Alternative Rebate Rules in the Provision of a Threshold Public Good: An Experimental Investigation', *Journal of Public Economics* 67: 195–220.

Martin, Edward G. (1986) 'Resource Mobilization, Water Allocation, and Farmer Organization in Hill Irrigation Systems in Nepal', PhD dissertation. Ithaca, NY: Cornell University.

Martin, Edward G. and Robert Yoder (1983a) 'Review of Farmer-Managed Irrigation in Nepal', in *Water Management in Nepal: Proceedings of the Seminar on Water Management Issues, 31 July–2 August,* pp. 82–91. Kathmandu, Nepal: Ministry of Agriculture, Agricultural Projects Services Centre, and the Agricultural Development Council.

Martin, Edward G. and Robert Yoder (1983b) 'The Chherlung Thulo Kulo: A Case Study of a Farmer-Managed Irrigation System', in *Water Management in Nepal: Proceedings of the Seminar on Water Management Issues, 31 July–2 August,* pp. 203–17. Kathmandu, Nepal: Ministry of Agriculture, Agricultural Projects Services Centre, and the Agricultural Development Council.

Martin, Edward G. and Robert Yoder (1983c) 'Water Allocation and Resource Mobilization for Irrigation: A Comparison of Two Systems in Nepal', Paper presented at the annual meeting of the Nepal Studies Association, University of Wisconsin, Madison, 4–6 November.

Marwell, Gerald and Pamela Oliver (1993) *The Critical Mass in Collective Action: A Micro-Social Theory*. New York: Cambridge University Press.

McCay, Bonnie J. (1992) 'Everyone's Concern, Whose Responsibility?: The Problem of the Commons', in S. Ortiz and S. Lees (eds) *Understanding Economic Process: Monographs in Economic Anthropology,* No. 10. Lanham, MD: University Press of America.

McCay, Bonnie J., Ian Wright, Richard Apostle and Leigh Mazany (1996) 'Fleet Concentration in an ITQ Fishery: A Case Study of the Southwest Nova Scotia Mobile Gear Fleet', Paper presented at the sixth annual conference of the International Association for the Study of Common Property, Berkeley, CA, 5–8 June.

McKean, Margaret A. (1982) 'The Japanese Experience with Scarcity: Management of Traditional Common Lands', *Environmental Review* 6(2): 63–88.

McKean, Margaret A. (1992) 'Management of Traditional Common Lands (*Iriaichi*) in Japan', in Daniel W. Bromley et al. (eds) *Making the Commons Work: Theory, Practice, and Policy*, pp. 63–98. San Francisco, CA: Institute for Contemporary Studies Press.

Merlo, M. (1989) 'The Experience of the Village Communities in the North-Eastern Italian Alps', in M. Merlo et al. (eds) *Collective Forest Land Tenure and Rural Development in Italy*, pp. 1–54. Rome, Italy: Food and Agriculture Organization of the United Nations.

Migot-Adholla, Shem E., Peter Hazell, Benoit Blarel and Frank Place (1991) 'Indigenous Land Rights Systems in Sub-Saharan Africa: A Constraint on Productivity?', *World Bank Economic Review* 5(1): 155–75.

Miller, David (1989) 'The Evolution of Mexico's Spiny Lobster Fishery', in Fikret Berkes (ed.) *Common Property Resources: Ecology and Community-Based Sustainable Development*, pp. 185–98. London: Belhaven Press.

Mitchell, Ronald B. (1995) 'Heterogeneities at Two Levels: States, Non-state Actors and Intentional Oil Pollution', in Robert O. Keohane and Elinor Ostrom (eds) *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains*, pp. 223–51. London: Sage.

Montias, John Michael (1976) *The Structure of Economic Systems*. New Haven, CT: Yale University Press.

Musgrave, Richard A. (1959) *The Theory of Public Finance*. New York: McGraw-Hill.

Netting, Robert McC. (1976) 'What Alpine Peasants Have in Common: Observations on Communal Tenure in a Swiss Village', *Human Ecology* 4: 135–46.

Netting, Robert McC. (1981) *Balancing on an Alp: Ecological Change and Continuity in a Swiss Mountain Community*. New York: Cambridge University Press.

Nugent, Jeffrey B. and Nicolas Sanchez (1993) 'Tribes, Chiefs, and Transhumance: A Comparative Institutional Analysis', *Economic Development and Cultural Change* 42: 87–113.

Nugent, Jeffrey B. and Nicolas Sanchez (1995) 'The Local Variability of Rainfall and Tribal Institutions: The Case of Sudan', Paper presented to the Middle East Economic Association, Washington, DC, 7 January.

Olson, Mancur (1965) *The Logic of Collective Action: Public Goods and the Theory of Groups*. Cambridge, MA: Harvard University Press.

Oppenheimer, Joe, Norm Frohlich, T. Hunt and H. Wagner (1975) 'Alternative Models of Contributions for Collective Goods', *Journal of Conflict Resolution* 9(2): 310–29.

Örebech, Peter (1982) *Konsesjoner i fisket*. Oslo, Norway: TANO.

Örebech, Peter (1993) 'Common and Public Property Rights Regimes to Non-Private Resources. Some Legal Issues on Self-Governing Conservation Systems', in Erling Berge (ed.) *Common Property Regimes: Law and Management of Non-Private Resources; Proceedings of the Conference,* Vol. I. Ås, Norway: The Agricultural University of Norway.

Ostrom, Elinor (1990) *Governing the Commons: The Evolution of Institutions for Collective Action*. New York: Cambridge University Press.

Ostrom, Elinor (1992) 'The Rudiments of a Theory of the Origins, Survival, and Performance of Common-Property Institutions', in Daniel W. Bromley et al. (eds) *Making the Commons*

Work: Theory, Practice, and Policy, pp. 293–318. San Francisco, CA: Institute for Contemporary Studies Press.
Ostrom, Elinor (1996) 'Incentives, Rules of the Game, and Development', in *Proceedings of the Annual World Bank Conference on Development Economics 1995,* pp. 207–34. Washington, D.C.: The World Bank.
Ostrom, Elinor, Thomas Dietz, Nives Dolsak, Paul C. Stern, Susan Stonich and Elke Weber, eds (2002) *The Drama of the Commons*. Committee on the Human Dimensions of Global Change. Washington, D.C.: National Research Council, National Academy Press.
Ostrom, Elinor, Roy Gardner and James M. Walker (1994) *Rules, Games, and Common-Pool Resources*. Ann Arbor, MI: University of Michigan Press.
Ostrom, Elinor and Edella Schlager (1996) 'The Formation of Property Rights', in Susan Hanna, Carl Folke, and Karl-Göran Mäler (eds) *Rights to Nature*, pp. 127–56. Washington, D.C.: Island Press.
Ostrom, Vincent and Elinor Ostrom (1977) 'A Theory for Institutional Analysis of Common Pool Problems', in Garrett Hardin and John Baden (eds) *Managing the Commons*, pp. 157–72. San Francisco, CA: W.H. Freeman.
Oye, Kenneth A. and James H. Maxwell (1995) 'Self-interest and Environmental Management', in Robert O. Keohane and Elinor Ostrom (eds) *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains*, pp. 191–221. London: Sage,
Pinkerton, Evelyn (1992) 'Conclusions: Where Do We Go From Here? The Future of Traditional Ecological Knowledge and Resource Management in Canadian Native Communities', in P. Boothroyd and B. Sadler (eds) *Traditional Ecological Knowledge and Environmental Assessment*. Ottawa: Canadian Environmental Assessment Research Council.
Pinkerton, Evelyn (1994) 'Local Fisheries Co-Management: A Review of International Experiences and Their Implications for Salmon Management in British Columbia', *Canadian Journal of Fisheries and Aquatic Sciences* 51: 2363–78.
Place, Frank and Peter Hazell (1993) 'Productivity Effects of Indigenous Land Tenure Systems in Sub-Saharan Africa', *American Journal of Agricultural Economics* 75: 10–19.
Raychaudhuri, Bikash (1980) *The Moon and the Net: Study of a Transient Community of Fishermen at Jambudwip*. Calcutta: Government of India Press, Anthropological Survey of India.
Rose, Carol M. (2002) 'Common Property, Regulatory Property, and Environmental Protection: Comparing Community-Based Management to Tradable Environmental Allowances', in Elinor Ostrom, Thomas Dietz, Nives Dolsak, Paul C. Stern, Susan Stonich, and Elke U. Weber (eds) *The Drama of the Commons*, pp. 233–58. Washington, D.C.: National Academy Press.
Samuelson, P. A. (1954) 'The Pure Theory of Public Expenditure', *Review of Economics and Statistics* 36(Nov.): 387–9.
Sandberg, Audun (1993) 'The Analytical Importance of Property Rights to Northern Resources', Colloquium presentation, Indiana University, Bloomington, Workshop in Political Theory and Policy Analysis, 27 September.
Sandberg, Audun (1996a) 'A European Debate Revisited', Working paper. Bodö, Norway: Nordland College.
Sandberg, Audun (1996b) 'Against the Wind: On Reintroducing Commons Law in Modern Society', Paper presented at the sixth annual conference of the International Association for the Study of Common Property, Berkeley, CA, 5–8 June.
Sandberg, Audun (2001) *Institutional Challenges for Common Property Resources in the Nordic Countries*. Stockholm: Nordregio.
Sandler, Todd (1997) *Global Challenges. An Approach to Environmental, Political, and Economics Problems*. Cambridge: Cambridge University Press.
Sandler, Todd (1998) 'Global and Regional Public Goods: A Prognosis for Collective Action', *Fiscal Studies* 19(3): 221–47.

Schelling, Thomas C. (1973) 'Hockey Helmets, Concealed Weapons, and Daylight Savings: A Study of Binary Choices with Externalities', *Journal of Conflict Resolution* 17(3): 381–428.
Schelling, Thomas C. (1994) 'Fishers' Institutional Responses to Common-Pool Resource Dilemmas', in Elinor Ostrom, Roy Gardner, and James M. Walker (eds) *Rules, Games, and Common-Pool Resources,* pp. 247–65. Ann Arbor: University of Michigan Press.
Schlager, Edella (1994) 'Fishers' Institutional Responses to Common-Pool Resource Dilemmas', in Elinor Ostrom, Roy Gardner, and James Walker (eds) *Rules, Games, and Common-Pool Resources*, pp. 247–66. Ann Arbor: University of Michigan Press.
Schlager, Edella and William Blomquist (1998) 'Heterogeneity and Common Pool Resource Management', in Edna Loehman and D. Marc Kilgour (eds) *Designing Institutions for Environmental and Resource Management,* pp. 101–13. Cheltenham, UK: Edward Elgar.
Schlager, Edella, William Blomquist and Shui Yan Tang (1994) 'Mobile Flows, Storage, and Self-Organized Institutions for Governing Common-Pool Resources', *Land Economics* 70(3): 294–317.
Schlager, Edella and Elinor Ostrom (1992) 'Property Rights Regimes and Natural Resources: A Conceptual Analysis', *Land Economics* 68(3): 249–62.
Seabright, Paul (1993) 'Managing Local Commons: Theoretical Issues in Incentive Design', *Journal of Economic Perspectives* 7(4): 113–34.
Sengupta, Nirmal (1991) *Managing Common Property: Irrigation in India and the Philippines*. New Delhi: Sage.
Sengupta, Nirmal (1993) *User-Friendly Irrigation Designs*. New Delhi: Sage.
Sethi, Rajiv and E. Somanathan (1996) 'The Evolution of Social Norms in Common Property Resource Use', *The American Economic Review* 86(4): 766–88.
Shivakoti, Ganesh P. and Elinor Ostrom, eds (2002) *Improving Irrigation Governance and Management in Nepal*. Oakland, CA: Institute for Contemporary Studies Press.
Singh, Katar (1994) *Managing Common Pool Resources: Principles and Case Studies*. New Delhi: Oxford University Press.
Singh, Katar and V. Ballabh (1996) *Cooperative Management of Natural Resources*. New Delhi: Sage.
Siy, Robert Y., Jr (1982) *Community Resource Management: Lessons from the Zanjera*. Quezon City, Philippines: University of the Philippines Press.
Stern, Paul, Thomas Dietz, Nives Dolsak, Elinor Ostrom and Susan Stonich (2002) in Elinor Ostrom, Thomas Dietz, Nives Dolak, Paul C. Stern, Susan Stonich and Elke U. Weber (eds) *The Drama of the Commons*, pp. 445–89. Washington, D.C.: National Academy Press.
Tang, Shui Yan (1992) *Institutions and Collective Action: Self-Governance in Irrigation*. San Francisco, CA: Institute for Contemporary Studies Press.
Tang, Shui Yan (1994) 'Building Community Organizations: Credible Commitment and the New Institutional Economics', *Human Systems Management* 13: 221–32.
Taylor, Michael (1987) *The Possibility of Cooperation*. New York: Cambridge University Press.
Taylor, Michael and H. Ward (1982) 'Chickens, Whales and Lumpy Goods: Alternative Models of Public Goods Provision', *Policy Studies* 30: 350–70.
Tietenberg, Tom (2002) 'The Tradable Permits Approach to Protecting the Commons: What Have We Learned?', in Elinor Ostrom, Thomas Dietz, Nives Dolsak, Paul C. Stern, Susan Stonich, and Elke U. Weber (eds) *The Drama of the Commons*, pp. 197–232. Washington, D.C.: National Academy Press.
van de Kragt, Alphons, John M. Orbell and Robyn M. Dawes (1983) 'The Minimal Contributing Set as a Solution to Public Goods Problems', *American Political Science Review* 77(Mar.): 112–22.
Vincent, Linden (1995) *Hill Irrigation: Water and Development in Mountain Agriculture*. London: Overseas Development Institute.

Wade, Robert (1992) 'Common-Property Resource Management in South Indian Villages', in Daniel W. Bromley et al. (eds) *Making the Commons Work: Theory, Practice, and Policy,* pp. 207–29. San Francisco, CA: Institute for Contemporary Studies Press.

Wilson, James A. (1995) 'When are Common Property Institutions Efficient?', Working paper. Orono: University of Maine, Department of Agriculture and Resource Economics.

Wilson, James A. and Lloyd M. Dickie (1995) 'Parametric Management of Fisheries: An Ecosystem-Social Approach', in Susan Hanna and Mohan Munasinghe (eds) *Property Rights in a Social and Ecological Context: Case Studies and Design Applications*. Washington, DC: The Beijer International Institute of Ecological Economics and The World Bank.

Wilson, James A., J. French, P. Kleban, S. R. McKay and R. Townsend (1991) 'Chaotic Dynamics in a Multiple Species Fishery: A Model of Community Predation', *Ecological Modelling* 58: 303–22.

Yandle, Tracy (2001) 'Market-Based Natural Resource Management: An Institutional Analysis of Individual Tradable Quotas in New Zealand's Commercial Fisheries', PhD dissertation, Indiana University.

Yandle, Tracy and Christopher M. Dewees (2003) 'Privatizing the Commons Twelve Years Later: Fishers' Experiences with New Zealand's Market-Based Fisheries Management', in Nives Dolsak and Elinor Ostrom (eds) *The Commons in the New Millennium: Challenges and Adaptations*, pp. 107–27. Cambridge, MA: MIT Press.

ELINOR OSTROM is the Arthur F. Bentley Professor of Political Science and Co-Director of the Workshop in Political Theory and Policy Analysis, and the Center for the Study of Institutions, Population, and Environmental Change, Indiana University, Bloomington. She was elected to the National Academy of Sciences in 2001; is a member of the American Academy of Arts and Sciences; and a recipient of the Frank E. Seidman Prize in Political Economy and the Johan Skytte Prize in Political Science. Her books include *Governing the Commons: The Evolution of Institutions for Collective Action*; *Rules, Games, and Common-Pool Resources* (with Roy Gardner and James Walker); and *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains* (with Robert Keohane). ADDRESS: Workshop in Political Theory and Policy Analysis, Indiana University, 513 North Park Street, Bloomington, Indiana 47408, USA [email: ostrom@indiana.edu].