GOVERNING THE COMMONS.

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Analyzing institutional change

In the preceding chapter I examined institutions for governing CPRs in which appropriators have devised governance systems that have survived for long periods of time in environments characterized by considerable uncertainty and change. Although the particular problems involved in governing mountain commons vary from those involved in governing irrigation systems, all of these long-enduring institutional arrangements have shared commonalities. These cases clearly demonstrate the feasibility (but obviously not the likelihood) of robust, self-governing institutions for managing complex CPR situations, but the origins of these systems are lost in time. It is not possible to reconstruct how earlier users of Swiss alpine meadows, Japanese mountain commons, the Spanish *huertas*, or the Philippine *zanjeras* devised rules that have survived such long periods. We do not know who originated or opposed various proposals, or anything about the process of change itself.

A study of the origins of institutions must address the problem of supply raised in Chapter 2. As Bates (1988) points out, the presence of collective benefits as a result of designing new institutions is itself a second-order collective dilemma. A proposed new institution "is subject to the very incentive problems it is supposed to resolve" (Bates 1988, p. 395). Many questions need to be addressed. How many participants were involved? What was their internal group structure? Who initiated action? Who paid the costs of entrepreneurial activities? What kind of information did participants have about their situation? What were the risks and exposures of various participants? What broader institutions did participants use in establishing new rules? These questions are rarely answered in the extensive case-study literature describing behavior within ongoing institutional arrangements. Once a set of rules is in place, the incentives facing

appropriators are entirely different from the incentives that faced an earlier set of appropriators when confronted with severe appropriation or provision suboptimalities.

In this chapter, the origins of a set of institutions to manage a series of groundwater basins located beneath the Los Angeles metropolitan area are examined. Louis Weschler and I did extensive fieldwork in these areas during the late 1950s and early 1960s, when many changes were occurring (E. Ostrom 1965; Weschler 1968). We attended meetings, read internal memoranda, and interviewed participants to obtain information about the strategies of groundwater producers to organize voluntary associations, to undertake litigation, to create special districts, and to constitute a complex public-private governance system to regulate their basins. Recently, William Blomquist (1987a, 1988a–e) has expanded the number of groundwater basins studied and updated the available information. For these groundwater basins, we have a good understanding of the processes involved in changing the rules, and sufficient time has elapsed to allow us to evaluate the stability and efficiency of the results obtained in using these rules to govern and manage these basins. In this chapter we examine the processes of changing the rules in three basins (Raymond, West, and Central) that have relied on negotiated settlements of water rights as a key element in the transformation of their situation.[1] See Figure 4.1 for a map of the area.

THE COMPETITIVE PUMPING RACE

The setting

In an earlier geologic era, rivers and streams draining the mountains surrounding what has now become the Los Angeles metropolitan area laid down wide and deep bands of sand and gravel that were then partially overlaid by hard layers of clay. The former streambeds are now deep, water-bearing strata that can be thought of as underground reservoirs. These reservoirs are replenished by the rains that fall in the foothills and upper valleys and, to a more limited extent, by precipitation and drainage on the flat coastal plain itself.

In a semiarid region such as Los Angeles, groundwater basins are extremely valuable when used in conjunction with surface supply systems. First, they are sources of inexpensive and high-quality water, as compared with the cost of importing water from long distances. In 1985, the Metropolitan Water District charged $240 per acre-foot (the volume of water that would cover one acre of land with one foot of water) as the wholesale price for imported water from northern California and from the Colorado

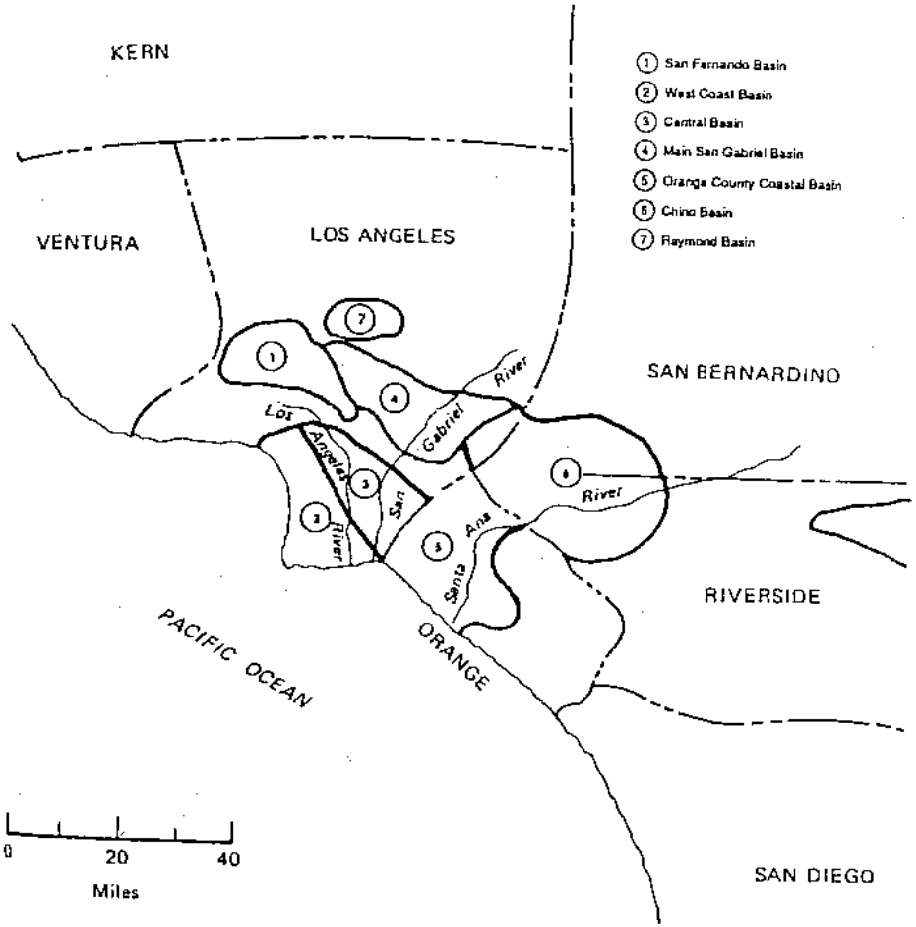

Figure 4.1. Groundwater basins underlying the south coastal plain in California. (Adapted from Lipson 1978.)

River. The cost of pumping groundwater in the Los Angeles area averaged around $134 per acre-foot – a saving of more than $100 per acre-foot. If the 282,458 acre-feet of groundwater that were pumped in 1985 from the three basins discussed in this chapter had been replaced with surface water, it would have cost the industrial users, the urban households, and the irrigators at least $28 million more per year.[2]

The value of the basins as sources of water supply is overshadowed, however, by their even greater value as natural storage vessels that can retain water for use during periods of peak demand.[3] Every surface-water system must have available some type of short-term storage so that it can rapidly meet the accelerated demands of water users that occur at regular intervals during each day and each week, and during the course of a year. The current construction costs for a water tower in the Los Angeles area average around $57,500 per acre-foot (Blomquist 1987a). The minimum amount of short-term storage recommended by the relevant engineering standards is 16% of the total water used in an area. In the area of the West Basin, with an annual demand for water of 327,435 acre-feet, storage reservoirs that could hold 52,400 acre-feet would be required if the basin were not available for this purpose. The replacement costs for this single basin would be about $3.01 billion. The loss of all the groundwater basins underlying the Los Angeles metropolitan area would be an economic disaster of major proportions.

Groundwater basins can be destroyed by overextraction and/or pollution. If more water is withdrawn per year than the average level of replenishment (referred to as the safe yield of a basin), eventually the gravel and sand in the water-bearing strata will compact so that they cannot hold as much water as they formerly did. If a groundwater basin is located near the ocean, and its water level is drawn down below sea level, saltwater intrusion will occur along the coast. Wells along the coastline must be abandoned. If intrusion is not halted, eventually the entire basin will no longer be usable as a source of supply or for its storage capacity. Overextraction threatened all of the groundwater basins in this region until institutional changes were initiated by those affected.

The logic of the water-rights game

Overextraction was the logical outcome of the way groundwater rights were defined prior to the institutional changes described in this chapter. Water rights in California had been defined on the basis of whether a producer owned the overlying land and used the water on that land (an overlying landowner) or used the water to serve areas other than land

owned by the water producer (an appropriator). Under the common law, an overlying landowner held a riparian right to the "full flow" of the water supply underlying his or her land (Nunn 1985). In a region of extreme scarcity of water, the common law does not provide secure rights for an overlying landowner. Water underlying any parcel of land (e.g., parcel A) can be siphoned to a neighbor's land if the neighbor withdraws water more rapidly than does the owner of parcel A. In *Katz v. Walkinshaw* [141 Cal. 116, 74 P. 766 (1903)], the doctrine of "correlative rights" was developed to replace the strict interpretation of riparian rights. That doctrine held that in times of shortage, if the court was called on to adjudicate among competing interests, the court would treat all overlying owners as correlative and coequal owners. In times of scarcity, each would gain a *proportionate* share of the water rather than an *absolute* share of the water. That doctrine was modified somewhat in *San Bernardino v. Riverside* [186 Cal. 7 (1921)], in which overlying landowners were limited to taking only water that they could put to "beneficial" use.

Thus, overlying landowners facing only other overlying landowners knew that if they went to court to settle a dispute over water rights during a time of shortage, they would all share proportionately in any cutback in the total water available to them. In most groundwater basins, however, overlying landowners faced other water users called "appropriators," whose claim to water was on a different basis than that of an overlying landowner. Appropriators pumped groundwater to be used on land not owned by those withdrawing the water. Most private and public water companies were legally classified as appropriators, because the water they pumped was used by their customers, not by the water companies themselves. Nonoverlying landowners were allowed, if not encouraged, by the appropriative-rights doctrines made part of the statutory law in 1872 to withdraw "surplus water" or water that was not being put to beneficial use by the overlying landowners. The key elements in defining the rights of an appropriator had to do with

1 when the appropriator began to withdraw water from the source,
2 how much water was actually put to beneficial use, and
3 whether or not the use was continuous.

Under the doctrine of "first in time, first in right," appropriators acquired rights depending on their history of use. Among appropriators, a court-resolved conflict over a scarce supply would exclude use by the most junior appropriator, and then the next most junior appropriator, and so forth. The most senior appropriators would be fully protected against encroachment on their rights by more junior appropriators. However, the rights of

the most senior appropriators were potentially subordinate to those of overlying landowners.

The simultaneous existence of the doctrines of correlative and appropriative rights in the same state introduced considerable uncertainty about the relative rights of one groundwater producer against others. The uncertainty was compounded by the presence of a third common-law doctrine that enabled groundwater producers to gain rights through "adverse use" or prescription. In regard to land, prescriptive rights are relatively straightforward: If one person occupied someone else's land in an open, notorious, and continuous manner for a set period of time (five years in California), and the owner makes no effort to eject the occupier, the original owner loses the right to the land.

In regard to groundwater, possession of water was not enough to establish open and *adverse* use. Any junior appropriator could legally use any water that was surplus water. Surplus water was defined as a part of the "safe yield" of a basin that was not of beneficial use to overlying landowners or senior appropriators. The safe yield of a basin is the average, long-term supply of water to the basin. If that quantity of water was put to beneficial use, no surplus was available to others. An appropriator had to take nonsurplus water openly and continuously for more than five years to perfect prescriptive rights. Once perfected, prescriptive rights were superior to those of overlying owners and appropriators. The same actions of an appropriator – openly taking water continuously from a basin – could lead to the acquisition of rights *superior* to those of overlying landowners or, alternatively, to the *inferior* rights of a junior appropriator relative to an overlying landowner in time of scarcity. The key difference between these outcomes was whether the court ruled that a surplus did or did not exist for the five-year period prior to litigation. Given that all producers suffered from lack of information concerning the safe yield of a basin and the pumping rates of other producers, no one knew at the time of making such decisions what the pumping rates were or whether or not a surplus existed.

The situation in these basins can be characterized as an open-access CPR for which clear limits have not been established regarding who can withdraw how much water. In such situations, two strong pressures encourage pumpers to adopt inefficient strategies. The first is a pumping-cost externality. The second is a strategic externality (Negri 1989). Pumping costs increase as the pumping lift increases, because of falling water levels, and therefore each person's withdrawals increase the pumping costs for others. No one bears the full cost of personal actions. Each pumper is consequently

led toward overexploitation. The strategic externality involved in an open-access groundwater basin is aptly described by Negri (1989, p. 9).

> With property rights undefined and access nonexclusive, the "rule of capture" governs the "ownership" of the reserve stock. The rule of capture grants [pumpers] exclusive rights to that portion of the groundwater that they pump. What an operator does not withdraw today will be withdrawn, at least in part, by rival[s]. The fear that [pumpers] cannot capture tomorrow what they do not pump today undermines their incentive to forgo current pumping for future pumping.

The two incentives reinforce one another to aggravate the intensity of the pumping race. Without a change of institutions, pumpers in such a situation acting independently will severely overexploit the resource. Overexploitation can lead to destruction of the resource itself.

Current institutions affect not only the intensity of a pumping race but also the relative incentives of different participants to initiate institutional change. Given the legal structure of rights in California, overlying landowners were more motivated than appropriators to launch court action so as to keep appropriators from obtaining prescriptive rights. The decision about when to start litigation, however, involved high risks of being too soon or too late. The overlying owner faced two possibilities:

> (1) If he went to court before all "surplus" water had been appropriated, and the court ruled that the water being diverted by the defendant was indeed surplus water, the overlying owner would suffer the costs of the litigation and receive no remedy;
> (2) If he waited too long to go to court, the overlying owner might find that the defendant had perfected a prescriptive right if the court ruled that the water being diverted was non-surplus water. There was, in other words, no way for the overlying owner, on whom the burden of initiating litigation rested, to succeed in protecting his right until it had been invaded, and yet within a short time after the right had been invaded, the overlying owner would have lost the right he sought to protect due to prescription.
>
> (Blomquist 1988a, p. 19)

The uncertainty of the competing water doctrines was compounded by the uncertainty shared by all water producers about the actual supply of water to a basin and the quantity of water withdrawn by all of the parties. It was essential to know the quantities supplied and demanded from a basin to determine the presence or absence of a surplus. Both types of information were costly to obtain. Both could be obtained at the time of litigation

by asking the court to appoint a watermaster to make a geologic survey of the basin and determine its water supply and to obtain information about the past water uses of all producers. When determined in this manner, the cost would be shared by all producers involved in the litigation. But that did not solve the problem of uncertainty prior to the initiation of litigation. In past cases, signs of potential problems – such as falling water tables – had not been accepted by the court as sufficient evidence of a water shortage to declare a lack of surplus and uphold the rights of overlying owners as against junior appropriators [*San Bernardino v. Riverside*, 186 Cal. 7 (1921)].

Given these compound uncertainties, it is easy to explain the behavior of groundwater pumpers in the Los Angeles metropolitan area during the first 50 years of this century. To obtain any kind of water right, one needed to show continuous withdrawal of water and application to beneficial use. In that environment of legal uncertainty, attorneys advised producers to pump as much as they needed and to defend later (Krieger 1955). A pumping race occurred in each of the groundwater basins underlying the Los Angeles area.

Given those incentives, many water producers and local government officials during the 1940s and 1950s worried that all of the basins would be severely overdrawn and that those basins located adjacent to the ocean – West Basin and Central Basin – would be lost to the sea. By the 1960s, however, the pumping race had been halted in all of the coastal basins. Water rights were eventually established in all the basins, except in Orange County, which continues to rely on a pump tax for regulation.[4]

Special water districts have been established throughout the area to obtain surface water, to levy pump taxes on water production, and to replenish the basins through a variety of artificial means. A series of injection wells has been constructed along the coast to create a barrier of fresh water against the sea, enabling the coastal districts to regulate the uses of their basins in a manner similar to the use of a surface reservoir. In other words, diverse private and public actors have extricated themselves from the perversity of the pumping race and transformed the entire structure of the incentives they face. Public arenas were involved in many stages of these developments. The initial steps were taken in the shadow of a court order. Elections and public hearings were held at key stages. The solutions to the pumping race, however were not imposed on the participants by external authorities. Rather, the participants used public arenas *to impose constraints on themselves*. Because litigation to gain defined water rights was involved in all of the basins, except in Orange County, we first discuss this strategy to transform the pumping race.

THE LITIGATION GAME

The Raymond Basin negotiations[5]

The Raymond Basin is a small basin, with a surface area of 40 square miles, located inland and thus protected from saltwater intrusion. The area was already highly developed by the turn of the century. Later studies have revealed that the safe yield of the basin was steadily exceeded from 1913 onward. The cities of Pasadena, Sierra Madre, Arcadia, Altadena, La Cañada–Flintridge, South Pasadena, San Marino, and Monrovia are located on the surface of the basin. The city of Alhambra lies on its borders and appropriates water from the basin for use within its boundaries. The city of Pasadena was by far the largest producer of water from the basin – its production equaled the production of the other 30 producers combined. Pasadena thus approached, but did not reach, the position of a dominant actor in a privileged group (Olson 1965). According to Olson's model, if the Raymond Basin producers had been a privileged group, the city of Pasadena would have borne all of the costs associated with stopping the pumping race. The prediction one derives from Olson's model is consistent with some, but not all, of the activities pursued by the city of Pasadena.

The city of Pasadena for some years adopted the strategy of the dominant player in a privileged group. From 1914 to 1923, for example, the city replenished the basin by capturing floodwaters and spreading them on the gravel areas located at the feet of the San Gabriel Mountains. The water that percolated into the basin was then available for capture by the city of Pasadena as well as by other groundwater producers. In the late 1920s, the city of Pasadena was a leading participant in the formation of the Metropolitan Water District of Southern California, which would eventually construct an aqueduct to bring water 250 miles to the Los Angeles area from the Colorado River.

During the 1930s, however, the city of Pasadena was no longer willing to undertake independent actions that were substantially benefiting others who were not contributing to the costs. The city tried unsuccessfully to negotiate a voluntary settlement with the other producers whereby all producers would jointly reduce the amounts of water they were withdrawing from the basin. In 1937 Pasadena initiated legal proceedings against the city of Alhambra and 30 other producers.[6] The case was referred to the Division of Water Resources of the California Department of Public Works for determination of the geologic structure of the basin, the safe yield of the basin, and whether or not there was a surplus.

That referral procedure was time-consuming and costly. The draft report of the referee was not completed until March of 1943 and cost about

$53,000. The referee found that the yearly withdrawals from the basin were 29,400 acre-feet, whereas the safe yield of the basin was 21,900, leading to an annual overdraft of 8,500 acre-feet per year. The referee recommended that the parties curtail their pumping to the safe yield of the basin.

The parties then shared a single, authoritative "image" of the problem they faced. They also would confront a new "default condition" (E. Ostrom 1986a) if they could not agree on their own solution. Prior to litigation, the failure to agree would simply mean a return to the pumping race. Once the court took jurisdiction, an absence of agreement would mean that the judge would decide which parties had to bear the brunt of the cutback. It was not at all clear what the judge would decide. The judge might, for example, assign preeminent rights to the overlying owners and then assign the remainder of the 21,900 acre-feet as a "surplus" to the appropriators to be apportioned according to their seniority. Or the judge might decide that there was no surplus. In that case, senior appropriators might be granted prescriptive rights, and overlying landowners would bear the major brunt of the cutback.

A simplified picture of the bargaining problem that the producers faced is shown in Figure 4.2. If we assume that the overlying owners were withdrawing 12,000 acre-feet and the appropriators (who might become prescriptors) were withdrawing 18,000 acre-feet, the total withdrawals prior to a decision would be 30,000 acre-feet. Everyone accepted the fact that a cutback to 22,000 acre-feet would occur. A worst-case analysis done by the overlying landowners would assume that the judge would declare that there had been no surplus for more than five years prior to litigation. Thus, the appropriators would be given superior rights to all that they had withdrawn. They would be assigned 18,000 acre-feet, leaving only 4,000 acre-feet for the overlying landowners. Point B marks the worst possible solution that the overlying owners could face.

Similarly, the appropriators could do a worst-case analysis and assume that the judge would assign firm rights of 12,000 acre-feet to the overlying landowners and then assign the "surplus" of 10,000 acre-feet to the appropriators according to their seniority. Point A is the worst possible solution from the perspective of the appropriators. For all participants, the range of variation between complete protection and major loss (the line connecting A and B) would be considerable. Further, a fully contested trial would last a long time, given the conflicting legal doctrines, and the costs of litigation would be extremely high.

At the instigation of the city of Pasadena, the parties held some serious negotiations in the shadow of the court. Within six months they had

drafted a stipulated agreement signed by all but 2 of the 32 parties involved in the litigation. The negotiation process was furthered in that instance by the unusual fact that one attorney, Kenneth Wright, represented 16 of the parties. After another six months, one of the holdouts also agreed to the stipulation. The other – the California-Michigan Land and Water Company – never agreed to the stipulation and challenged the final court decision based on the stipulation.

The signatories agreed that the safe yield had been exceeded for a long time and that it was necessary to cut back to the safe yield of the basin. They stated that each producer's withdrawal of groundwater had been open, continuous, and notorious and was, because of the overdraft, adverse to the claims of all of the others. Thus, each producer had prescribed against all of the others. The term "mutual prescription" has been used to describe the concept used by these parties as the foundation for their negotiated settlement. The signatory parties agreed to *share the cutback proportionately* instead of pursuing further legal procedures to determine whose rights took precedence.[7] The proportional division of the cutback is represented by point D in Figure 4.2.[8] They further guaranteed each other's proportional shares of the safe yield (if it were to change in the future) and established an arrangement to enable those most adversely affected by the

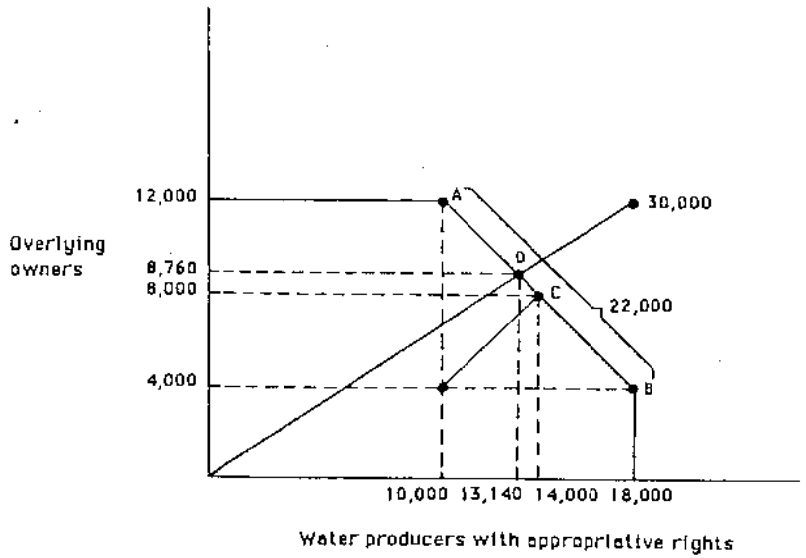

Figure 4.2. The bargaining situation faced by overlying owners and appropriators.

cutback to obtain exchange rights from others willing to sell their rights on an annual basis.

A short trial was held to hear the objections of the California-Michigan Land and Water Company and to assign the Division of Water Resources of the California Department of Public Works to serve as the watermaster – an official monitor – to supervise the agreement. Rather than imposing his own solution,[9] the judge, after considerable reflection, issued a final judgment on December 23, 1944,[10] based on the stipulated agreement. The final judgment declared all of the decreed rights to be of equal standing in any future dispute and enjoined all parties from taking more than their decreed rights. The judgment continued the role of the watermaster to enforce the provisions of the judgment and to supervise the exchange pool they had developed. In addition to the leasing arrangements of the exchange pool, decreed rights could be leased or sold outright so long as the transfers were recorded by the watermaster. Two-third of the costs of the watermaster were to be paid for by the parties, and the state of California would pay for the remaining costs of monitoring the agreement. The case was appealed to the California Supreme Court, and the decision was upheld.[11] The United States Supreme Court declined to review the case.

By negotiating their own agreement, the parties had ended the pumping race faster and at a lower cost than they could have through a court proceeding.[12] They also had gained firm and marketable rights to defined shares of the safe yield of the basin. A market for those water rights developed, and most of the smaller right-holders have sold their rights to the water companies, for whom the rights have a higher value. There are now 17 active producers from the basin, and they are almost all municipal or private water companies. Only three overlying landowners continue to produce water from the basin. The areas within the basin that did not have access to imported water formed a municipal water corporation in 1953 and started receiving imported water in 1955.

The West Basin negotiations

West Basin, with a surface area of 170 square miles, is a much larger area than Raymond Basin. Located immediately adjacent to the ocean, it extends from the city of Inglewood to the Palos Verdes Peninsula. The situation in West Basin was not as favorable for negotiations as that facing the Raymond Basin producers. The major advantage for the West Basin producers was that their upland neighbors had already borne the costs of innovation and had developed a formula for reaching a negotiated settlement within the California legal environment that was considered to be fair

by many potential litigants. The disadvantages faced in West Basin included (1) a large number of producers (around 500 parties were named in the litigation), (2) the absence of a single dominant producer, and (3) considerable asymmetry in the risks regarding saltwater intrusion (those near the sea would lose their wells long before those pumping inland). The problem of the size of the group was offset to some extent by the concentrated nature of the groundwater production in the basin: 19 producers accounted for about 85% of the total quantity of water withdrawn from West Basin.[13]

The overdraft came a decade later to West Basin than to Raymond Basin. The heavy industrialization that occurred during World War II exacerbated the already growing overdraft, particularly because there were many oil companies located in the area whose water production had increased steadily. In the early 1940s, wells located along the coast began to show increasing salinity. Many water producers in the basin continued to believe, however, that the salinity in those wells was symptomatic of only a "local" problem immediately along the coast, not a more general problem that could affect their own situation in the future. During 1943, nine of the coastal municipalities met several times to discuss the importance of the increasing salinity of their wells. They agreed that more information was needed to gain a realistic and common image of the structure of the groundwater basin. Those cities signed a cooperative agreement with the United States Geological Survey and the Los Angeles County Flood Control District to undertake an initial study of the problem of groundwater supply in the basin.[14]

The report, completed in 1944, painted a grim picture. Wells all along the coast had been invaded by seawater. The investigators had found no natural barrier at any point in the basin to halt the advance of the sea. The entire basin was threatened with destruction. The report provided a common image of the general boundaries of the basin and the extent of the problem without providing an exact picture of the safe yield and current levels of water production. It was no longer possible, however, for producers to maintain that the salinity in the coastal wells was strictly a local problem.

In December of 1944, all of the major water producers met and established an ad hoc committee to consider what should be done next. That committee had three major recommendations:

1 that a permanent association be created of all interested water producers so that they could continue to discuss their mutual problems and possible joint actions,

2 that a technical survey be made of alternative sources of water for the area, and
3 that water producers consider initiating legal action similar to the action just completed in Raymond Basin to reduce total pumping and to ration the limited water supply in West Basin among all water producers (Ways and Means Committee 1945, p. 16).

All three recommendations were followed. The West Basin Water Association was created within a few months.[15] The association provided a continuous open forum[16] for discussion of all major steps taken in West Basin by producers and representatives of various local, regional, and state public agencies. The resources of the association frequently were used to obtain and make available the best possible technical information about the basin. Extensive minutes were kept for all West Basin Water Association meetings, as well as the meetings of the Executive Committee and most of the working committees of the association. Those files were open to all members, as well as to others interested in gaining information about past decisions, technical data, and studies of the benefits and costs of alternatives. A weekly newsletter was dispatched to all members from 1946 through 1954. The motto of the newsletter, according to its editor, was "let there be no surprises, either pleasant or unpleasant" (Fossette and Fossette 1986, p. 57). The practice of obtaining the best information available and disseminating it widely increased the degree of understanding and level of cooperation among the participants.

The first official act of the association, in March 1946, was to retain a renowned engineer, Harold Conkling, to examine the possibility of finding alternative sources of supplemental water for the basin. Conkling recommended the creation of a municipal water district to import water from the Metropolitan Water District of Southern California. Obtaining surface water eventually would mean that the groundwater basin would no longer serve as the major source of water for the area, but the question who would obtain rights to use the reservoir capacities of the basin had to be resolved.

Three appropriators initiated the West Basin litigation in October 1945: the California Water Service Company, the city of Torrance, and the Palos Verdes Water Company. Kenneth Wright, who had served as the attorney for the city of Pasadena in the Raymond Basin litigation, was the attorney for the California Water Service Company and had made several presentations to West Basin producers concerning the mutual-prescription concept used in the Raymond Basin case. Although the initiators of the litigation, and many other water producers in the basin, strongly supported the

concept of proportionate cutbacks by all water producers, several major water producers vigorously opposed such a plan.

The Dominguez Water Corporation, a senior appropriator with overlying rights as well, was one strong opponent. Because Dominguez was the largest producer from the basin,[17] it was unlikely that others would agree to a curtailment without the participation of the Dominguez Corporation. The city of Inglewood initially opposed the litigation and all of the actions proposed within the context of the West Basin Water Association. Inglewood's lawyers had advised city officials that its status as senior appropriator would protect it from having to cut back production. Inglewood's position changed, however, after the Raymond Basin decision had been sustained in the California Supreme Court.[18] Inglewood, which owned some wells near the sea, was to become an active participant in the effort to find solutions.

The city of Hawthorne, on the other hand, was located inland, and its people believed that their water supply was protected. Hawthorne adopted a hold-out strategy for many years. Thus, whereas the Raymond Basin case was a guiding model in the minds of the initiators of the litigation, it was not at all certain that the water producers of West Basin would achieve the high level of agreement needed to negotiate their own settlement. Once litigation had been initiated, however, the court could impose its own judgment if the water producers could not reach an agreement on their own. Thus, again the default rule had been changed by the initiation of litigation.

The case was referred to the Division of Water Resources of the California Department of Public Works. The difficult task of ascertaining the production levels for more than 500 producers and determining the geologic structure and inflow levels for a large and complex basin took four years. By the time the referee's report was completed, the decision of the trial court based on the stipulated agreement in the Raymond Basin case had been upheld by the California Supreme Court. Therefore, the West Basin water producers knew that the mutual-prescription concept could withstand a legal challenge by a private company.

The referee's findings and recommendations, however, came as a written bombshell. The referee found that overdrafts had been occurring since 1920 and that the safe yield of the basin was 30,000 acre-feet per year. The referee recommended a curtailment to the safe yield. By 1952, total groundwater withdrawals had reached 90,000 acre-feet per year. Even the supporters of mutual curtailment vigorously opposed a two-thirds reduction in groundwater production. Imported water had just begun to trickle

into the basin. Many water suppliers would not be able to meet their customers' demands if they were to reduce the quantity of water pumped by two-thirds. Early experiments with injection wells provided some encouraging indications that the supply of water to the basin could be increased. An increase in the supply would reduce the necessity of cutting back to the safe yield. The default condition, however, had again been changed. If the water producers were unable to arrive at their own settlement, they could expect the court to order a two-thirds cutback.

The West Basin Water Association provided a forum for serious negotiations about a settlement. The association established a Legal Settlement Committee composed of six attorneys and five engineers. The creation of the Legal Settlement Committee within the association changed the structure of the bargaining situation in subtle but important ways. Although the 11 committee members continued to represent the interests of their own firms, they were accountable to the members of the association as well. The association charged the committee with the responsibility for achieving *timely* curtailment of water production. The committee had to report quarterly to the full membership. The committee members would be subject to public criticism by respected colleagues if they simply pursued recalcitrant strategies and failed to find sources of agreement on which progress toward settlement could be based.[19] The members of this committee were expected to achieve an agreement whereby *all* parties would curtail their withdrawals. The first question to be resolved concerned how much curtailment.

The negotiators had to find a method to reduce withdrawals below 90,000 acre-feet and above the 30,000 acre-feet recommended by the referee. If the negotiated settlement was not above the referee's recommendation, some litigants would prefer to contest the matter in court in the hope that a judge would give their claims precedence over those of others. The engineers on the committee were asked to determine the maximum cutback that the parties could undertake in the near future without grave economic damage. The engineers concluded that a reduction of 25% to 30% could occur without serious economic harm to any water producer, if an exchange pool similar to the one devised in Raymond Basin were established.

Next the committee searched for a particular formula, based on the concept of mutual prescription, that would enable them to achieve a proportional cutback of 25% to 30%. Because 340 additional parties had been added to the case in 1949, one possibility was to use 1949 for determining shares, rather than the 1944 water year that immediately preceded the initiation of litigation. Using the referee's historical findings, the committee

compiled estimates of each party's "prescriptive rights" based on the 1944 water year versus the 1949 water year.[20] Their estimates totaled 44,387 acre-feet for 1944 and 63,728 for 1949. The committee proposed to use the 1949 data as the basis for negotiating an *interim* agreement that the parties could ratify immediately in order to achieve an actual cutback within a short time. One member of the committee reasoned that

> with the present usage in the amount of 90,000 acre-feet and . . . with the historical usage of 1949 amounting to 63,000 acre-feet or one-half way back to where the Division wanted the curtailment to go, a cutback to 1949 might be more acceptable at the present time . . . . [T]he parties would have enough water left under this arrangement to meet peak demands and it would afford a period in which to adjust to curtailment and . . . no one would be giving up any prescriptive rights already acquired. (West Basin Water Association, Legal Settlement Committee minutes, February 25, 1953, p. 4)

The interim agreement was drafted as a contingent contract. In other words, a water producer who signed the agreement and thus promised to curtail production to his own "Prescriptive Rights, 1949" was not committed to curtail until producers representing at least 80% of the total "Prescriptive Rights, 1949" had signed and the agreement was presented to and approved by the court. A signatory was committed to undertaking this "cooperative action" only if most of the other large water producers were also committed to the action. Thus, no one would be a "sucker," and the joint impact of their curtailments would make a substantial difference. By November 1954, agencies representing 82.5% of the total "Prescriptive Rights, 1949" had signed the agreement, and it was filed with the court. The court appointed the referee to continue as the official watermaster to ensure that the provisions of the agreement were followed.

It had taken two full years of negotiations and the threat of court action[21] to achieve this interim agreement, but at last a major change in the basic rules affecting the use of West Basin had occurred. Water levels in the basin rose immediately and continued to rise for several years, except in a water trough underlying the city of Hawthorne, which refused to sign the agreement.

The interim agreement was used for seven years while the water producers pursued other strategies to enhance the local water supplies, to replenish the basin, and to try to convince nonsignatories to agree to the curtailment. Two major parties did not sign. The first was the California Water Service Company, which had been one of the three initiators of the litigation and had borne a large share of the cost of the litigation. That company had not increased its water production after 1944, presuming that the litigation had protected its interests and that it could afford to take

an independent action to conserve water supplies. The choice of 1949, rather than 1944, as the date for determining rights meant that some of the water producers who had increased production during the four-year period gained somewhat proportionately, while California Water Service slipped behind a little in its proportionate share.[22]

Although it refused to sign the interim agreement, California Water Service Company voluntarily limited its own groundwater production. It did not pump any more water than allocated to it under the interim agreement. Consequently, the effect of the company's refusal to sign the interim agreement was to shift the burden of the cost of watermaster services back onto those who had gained proportionately more rights under the Agreement. The company's actions imposed no physical harm on others. Further, the company clearly did not plan to challenge efforts to make the interim agreement the basis for a final settlement.

On the other hand, the city of Hawthorne increased its withdrawals. By 1960, Hawthorne pumped more than 2,250 acre-feet in excess of its allocation under the interim agreement. During the period of the interim agreement, Hawthorne saved at least $100,000 by pumping more groundwater per year than it had been allotted. As Hawthorne's production increased, the pumping trough beneath the city continued to drop. The watermaster's report for 1960–1 (plate 4) shows that the 1961 water levels below Hawthorne averaged 30–40 feet below those for surrounding territories (California, State of, 1960–1). Nearby producers were harmed substantially.[23] The economic costs of Hawthorne's action were spread generally among all signatories who paid higher costs for imported water while Hawthorne continued to utilize the least expensive source of water.

From the perspective of Hawthorne's leaders, however, the problem seemed different. Instead of viewing the basin as something jointly owned by all water producers, Hawthorne viewed its needs to serve a municipality with water as superior to the needs of industry in the area. Hawthorne saw the interim agreement as favoring the industrial producers, an effort to take away water rights that should be devoted to public use. Hawthorne looked to other cities for support for its position. However, the beach communities had already suffered severe hardship because of saltwater intrusion. According to Hawthorne officials, those communities were willing to see any basis used to curtail production from the basin and slow down the saltwater intrusion. Hawthorne argued that the beach cities were giving away their rights.

During most of 1957 and 1958, the Legal Settlement Committee met weekly and sometimes biweekly trying to prepare a final agreement. The

technical problems of tracing all water-rights transactions for such a large group delayed the process substantially. The substantive problems were also considerable. Some signatories of the interim agreement opposed any final agreement that would not achieve curtailment down to the safe yield. Others preferred to wait until experiments with the saltwater barrier could establish the feasibility of being protected against the sea. The lack of *total* agreement to the interim agreement disturbed many who feared that Hawthorne or others might appeal. Given the experience of a costly appeal to the California Supreme Court in the Raymond Basin case, negotiators hoped to avoid an appeal of their settlement. Because the interim agreement afforded partial physical protection, many signatories believed that they had time to work out an agreement satisfactory to all parties.

Envoys were sent to the city of Hawthorne to urge city officials to reconsider their previous stance in regard to the interim agreement.[24] In 1958, the association appointed the mayor of Hawthorne to its Executive Committee in the hope that he would be able to change the attitude of other city officials. However, the attempts to reach an agreement with Hawthorne were unsuccessful. A final draft of a proposed "Agreement and Stipulation for Judgment" was presented to a meeting of the West Basin Water Association (WBWA) in February 1960. The Dominguez Water Corporation, as the largest water producer from the basin, gave the final agreement its full support by bringing signed copies of the agreement to the meeting. The city of El Segundo and Chanslor-Canfield Midway Oil Company joined Dominguez in this effort to show immediate support (WBWA minutes, February 25, 1960, p. 8). Three months later, 20 parties representing 32.5% of the total adjudicated rights had signed the agreement (WBWA minutes, May 26, 1960, p. 15). Obtaining the remaining signatures took one more year. By early summer of 1961, producers holding 82% of the adjudicated rights had signed the agreement. The Legal Settlement Committee indicated that it was unlikely that further signatures could be gained.

On July 21, 1961, 16 years after the litigation was initiated, a short trial was held, and the proposed judgment was presented to the court. The judgment was entered in August of 1961 substantially as presented to the court. As of October 1, 1961, all entities included as parties in the case were "perpetually enjoined and restrained from pumping or otherwise extracting from the Basin any water in excess of said party's Adjudicated Rights" (Judgment, *California Water Service Company et al. v. City of Compton et al.*, Civil Case No. 506806, Superior Court of the State of California in and for the County of Los Angeles, Sec. 5). Ninety-nine parties were found to

have adjudicated rights of 64,065 acre-feet.[25] The city of Hawthorne, like all nonsignatories, was placed under legal order to reduce its groundwater production to that stipulated in the agreement.

At the association meeting following the trial court's decision, a city councilman from the city of Hawthorne rose to congratulate the group on their "victory," but he warned them that his city planned to fight the decision "through every court in the land." The city of Hawthorne backed up that threat by retaining a firm of highly respected attorneys specializing in water law. At first, the association assumed the financial responsibility for supporting the judgment against the Hawthorne appeal. In 1962, when a Replenishment District had been formed, as described later, the new district undertook financial responsibility for defending the judgment, while the association maintained direct relations with the attorneys. After hearing the Hawthorne appeal, the District Court of Appeals concluded that the trial court had acted properly and affirmed its decision. After the California Supreme Court declined to review the decision made by the District Court of Appeals, the California Water Service case closed 18 years after it had opened.

No one really knows the exact costs involved in the West Basin litigation, given the large number of parties and the length of time involved, but the best available estimate is $3 million (Blomquist 1987a, p. 39). On the one hand, that was 10 times as expensive as the Raymond Basin negotiations. On the other hand, it was one-tenth of costs that would be involved in replacing the short-term storage capacities of the basin when used in conjunction with a surface supply. Amortizing the costs of the litigation over a 50-year period (as one would do for the construction of a major physical facility), the adjudication in Raymond Basin amounted to an annualized cost of 50 cents per acre-foot of water rights allocated, whereas the adjudication costs in West Basin amounted to an annualized cost of $2.50 per acre-foot of water rights (Blomquist 1987a, p. 39). In 1985, the annual costs of monitoring these water rights were $3.00 per acre-foot in Raymond Basin and $2.40 per acre-foot in West Basin.[26]

Adjudicating the water rights in West Basin was only one of a long series of steps taken by water producers to regulate their basin. Some of the subsequent steps are discussed later. The Raymond Basin and West Basin experiences were closely watched by water producers located in Central Basin. These producers also used court litigation as the setting in which to negotiate settlements of their individual rights to water. Central Basin is larger and more diverse than West Basin. Considerable effort was expended there to learn from the difficulties of the West Basin case and to adopt the process so as to reduce both the length of time needed to achieve

agreement and the high costs. The effort was successful on both counts. We now turn to a brief discussion of the Central Basin negotiation process.[27]

The Central Basin litigation

Overdraft conditions in Central Basin occurred much later than they had in Raymond Basin and West Basin. Central Basin is quite large (277 square miles of surface area) and was being used by around 750 owners of wells in the 1950s. The overdraft in Central Basin began in 1942. Most of Central Basin is located inland, and it is protected from the ocean on its western border by its downstream neighbor, West Basin. Thus, water producers in Central Basin are able to draw down their water levels farther than are those in West Basin without immediate adverse consequences. On the other hand, Central Basin does have a small southern exposure to the sea, and saltwater intrusion did begin to occur along that boundary as early as 1950.

At the prodding of their downstream neighbors, Central Basin water producers formed the Central Basin Water Association in 1950 using an organizational structure similar to that of West Basin. The part-time executive director of the West Basin Water Association became the part-time executive director of the newly formed Central Basin Water Association.[28]Some West Basin water producers were also active in Central Basin. Discussions immediately focused on the importance of achieving a negotiated settlement of the water rights in Central Basin. Central Basin producers, however, wanted to avoid the long delay and high cost of using the court-ordered reference procedure and avoid involving all of the very small water producers in the basin.

Consequently, instead of moving immediately toward the initiation of a suit, the Central Basin Water Association employed the services of a private engineering firm, well known for its expertise in the area of groundwater basins, to conduct an initial survey of conditions in the basin and of past water use. Further, a considerable effort was made to achieve a general agreement about the type of negotiated settlement they would reach before they actually went to court in 1962. An interim agreement, signed by parties holding 79% of the water rights, was approved by the court just 10 months after the litigation was initiated. The producers agreed to cut back production on a proportional basis by 20% and to establish a set of working rules modeled on the West Basin agreement, but also reflecting the particular circumstance in Central Basin. Watermaster services were initiated in October 1962. A voluntary cutback of approximately 45,000 acre-feet was initiated immediately (Fossette and Fossette 1986, p. 182). The

final settlement, signed by parties holding over 75% of the rights, was approved by a judge in October 1965 and went into effect in October 1966 – four years after initiation. The estimated costs of the Central Basin litigation were $450,000.

The litigation and negotiation processes in these three basins involved different problems and followed different paths. In Raymond Basin, the number of pumpers was relatively small, and one participant – the city of Pasadena – was more dominant than was any participant in West Basin or Central Basin. Pasadena withdrew about one-half of all water obtained from the basin. The city could not ignore the action of the other pumpers, because their actions could adversely affect joint outcomes. However, Pasadena had such a large stake in seeing that the basin was preserved that the city was willing to invest heavily in achieving a settlement. After failing to obtain a voluntary agreement to curtail pumping, the city initiated legal action and bore more than its proportionate share of litigation costs. By initiating efforts to obtain an external water supply and to control pumping from the basin before pumpers had become accustomed to withdrawal far in excess of safe yield, it was physically possible for all pumpers to cut back their water withdrawals and still serve the growing urban population settling in the area. The major asymmetry of interest faced by the litigants in Raymond Basin was their legal status as overlying owners or appropriators. By devising a new legal concept of mutual prescription, the parties found a basis to share the costs of curtailing groundwater production equitably. All pumpers could continue to use the basin for peaking purposes or could sell water rights, which had been well defined, to those who placed a higher value on acquiring such rights.[29]

Negotiators in West Basin faced three disadvantages not faced in Raymond Basin: (1) the large number of parties involved, (2) the absence of a dominant party, and (3) the asymmetrical risks faced by inland pumpers versus coastal pumpers. The negotiation process took longer, was more expensive, and involved a major conflict between coastal and inland pumpers. By using mutual prescription as the basis for an agreement, the parties reduced other potential asymmetries of interest that could have exacerbated the conflict. Once a final judgment was reached, all parties shared proportionately in the cost of curtailment. The process took sufficient time, however, that it became difficult to cut back to the safe yield and still serve the urban population, which had increased in the years following World War II. As discussed later, water producers in the area had to turn to other mechanisms to increase the supply of water to the groundwater basins, because the control over demand that they achieved did not bring the basin into balance.

Pumpers in Central Basin had several advantages in this process. Because the basin was very large and had only a small coastal section, pumpers could safely delay resolution of their water rights while they watched the process in the other basins. They were prodded into action by their downstream neighbors, who feared that lack of action in Central Basin might eventually negate the benefits of conservation in West Basin. By acting before it would be necessary to cut back much more than 20%, and using a private firm to gather much of the information before they went to court, Central Basin pumpers saved themselves considerable time and money in achieving a negotiated settlement based on the same principle that had been used in Raymond Basin and West Basin.

Conformance of parties to negotiated settlements

Forty-five years have passed since the judgment was entered in the Raymond Basin case, and 35 and 27 years have passed since the interim agreements were signed in West Basin and in Central Basin. Thus, the parties to these three agreements have had many occasions to decide whether or not to comply. Given the value of groundwater, the temptation not to comply must have been relatively great for all producers at one time or another in the combined 107 years of water use that have elapsed. However, the level of infractions has been insignificant during that time.

The watermaster in each basin has extensive monitoring and sanctioning authority. Monitoring activities are obvious and public. Every year, each party reports total groundwater extractions and receives a report listing the groundwater extractions of all other parties (or anyone else who has started to pump). The reliability of these records is high. Several agencies cross-check the records. The watermaster is authorized to calibrate all meters, thereby reducing the probability of one form of cheating. Given the accuracy of the information and its ease of access, each pumper knows what everyone else is doing, and each knows that his or her own groundwater extractions will be known by all others. Thus, the information available to the parties closely approximates "common knowledge," so frequently a necessary assumption for solutions to iterated dilemma games (Aumann 1976).

Instead of perceiving itself as an active policing agency, the watermaster service tries to be a neutral, monitoring agency. Because anyone who possesses a legal water right can initiate a court action to enforce compliance to the judgments, the watermaster does not need to initiate punitive actions against nonconformers. As expressed by an official of the watermaster service in 1960,

it is our policy not to take any affirmative actions against any party since this would place us in the position of being an active party in the action. Our policy has been to inform the active parties of any infringements and leave affirmative action up to them. We want to stay as neutral as possible in order to gain as much voluntary cooperation as possible.[30]

In the early years of the West Basin agreement, for example, the Moneta Water Company began to withdraw more than its allocation. After a couple of years, it was obvious that the overextractions were not accidental. In addition to listing Moneta's annual withdrawals in the tabular material included in all reports, the watermaster devoted several pages in an annual report to the recent activities of the company. The company began to comply with the judgment soon after the publication of those facts. Other than a few isolated incidents, handled in the same manner, the original litigants have complied with the curtailments without formal sanctions being imposed. Even the city of Hawthorne has curtailed its withdrawals to the stipulated amounts of the final judgment. It has been necessary, however, to initiate legal action against new pumpers who have attempted to withdraw groundwater without first purchasing water rights. Charges have been filed and defendants enjoined from groundwater production other than under the rights they eventually acquired by purchase.[31]

The levels of quasi-voluntary compliance with the final judgments in all of these court decisions have been extremely high. Although each pumper might be tempted from time to time to withdraw more water than legally allowed, each pumper wants total withdrawals from the basin constrained so that access to the storage and flow values of the resource will be continued over the long run. Given the active, reliable, and neutral monitoring of the watermaster service, no pumper can expect to overextract without everyone else learning about any noncompliance at the end of the next water year. Because everyone is organized and communicating with one another about joint strategies, continued noncompliance is likely to bring legal sanctions, as well as loss of reputation and the application of informal sanctions. Because a pumper is constrained, and almost all pumpers voluntarily agreed to the initial allocation of rights, the basic system is perceived to be fair by most participants. Further, participants continue to have control over the monitoring system to ensure that it continues to be active, fair, and reliable. Two-thirds of the watermaster's budget is paid for by those possessing water rights, and they can petition the court to appoint a different watermaster if they are not satisfied with performance.[32]

THE ENTREPRENEURSHIP GAME

Immediately after the interim agreement was signed in West Basin, and before litigation was initiated in Central Basin, West Basin water producers recognized that litigation was not a sufficient means to achieve long-term regulation of their basin. They took steps that culminated five years later in the creation of a new public enterprise and a series of agreements with surrounding public enterprises to manage West Basin and Central Basin as interconnected basins. The process of problem-solving and negotiation involved in the establishment of this new district and the series of agreements with existing agencies illustrates how public entrepreneurship can be used as a strategy to transform the structure of incentives facing those jointly using a CPR. The process of putting together the necessary components of a new enterprise was immensely complicated. Only a sketch can be presented here, but I try to present the problems the water producers faced, as they saw them, and the steps they took to try to solve them in the political environment they faced.

The litigation had left several unresolved questions. First, producers had been unwilling to cut back production to the safe yield. Although the cutbacks immediately improved water conditions, they were insufficient to achieve a final regulation of the basins. Either the replenishment of both basins had to be accelerated or further cutbacks in production were needed. If the replenishment rate could be increased, then it would be possible to use the underground storage capacity in a manner somewhat analogous to the use of surface storage facilities, whereby one draws down and then refills the facility repeatedly.[33]

A second unresolved, and related, problem was the specific danger that saltwater intrusion posed along the long western border of West Basin and the short southern border of Central Basin. Early in the 1960s, water engineers from West Basin and the Los Angeles County Flood Control District began to experiment with the concept of building a freshwater barrier against the sea. An initial experiment, funded in part by local sources and in part by the state of California, proved that it was both technically and economically feasible to construct a series of wells along the coast that could be used to inject fresh water under pressure into a groundwater basin. The resulting cone of fresh water would prevent further saltwater intrusion. Most of the fresh water would then be available at a later juncture to be withdrawn when needed. If such a barrier could be constructed along the entire coastline, the artificial recharge of the basin would be greatly enhanced, and the threat of the sea would be eliminated. Once the technical and economic feasibility had been established, the

question of exactly who would pay for the barrier, and how, remained to be resolved.

A third delicate question centered on the relevant boundary for managing West Basin and Central Basin. That question had not arisen in regard to Raymond Basin, which was an upland basin and relatively self-contained. Once water producers in West Basin reduced their pumping levels, while water producers in Central Basin continued heavy production, water from West Basin began to flow eastward into Central Basin, instead of westward from Central Basin into West Basin. That change in the direction of the "natural" water flow led producers in both basins to recognize how closely interconnected their two basins were. A barrier erected along the coast would afford protection not only for West Basin but also for Central Basin. Further, an open porous area in Central Basin could be used to replenish far more efficiently than any area located in West Basin. Water spread at that location could raise water levels in Central Basin, which, combined with a cutback in production in Central Basin, would increase the flow of water into West Basin.

No existing public agency had the authority or the appropriate boundaries to address these questions. Water producers in West Basin and Central Basin were reluctant to turn to any of the large-scale agencies currently in existence for fear that they would lose control of the decisions being made and might end up worse off.[34] In the fall of 1954, the president of the West Basin Water Association suggested to the president of the Conservation Association of Southern California that there was a need for representatives from all segments of the California water industry to meet and discuss potential legislation for solving critical groundwater problems. As a result, 45 agencies were invited to meet in September of 1954 "to draft equitable and effective ground water legislation for introduction at the 1955 Legislature" (letter from W. S. Rosecrans to the Central Basin Water Association). From that group, the "Committee of Twelve" was formed to draft legislation.[35]

Discussion of the proposed legislation centered on two types of changes. The first was designed to expedite future groundwater adjudications. The referee in the West Basin case had taken seven years to prepare a report because of lack of information concerning the historical patterns of water use by a large number of the producers. To correct that situation for the future, the committee drafted legislation to require all those who produced at least 25 acre-feet of groundwater per year to file notices of their annual extraction with a state agency. That legislation could not expedite the West Basin case, but it did provide some of the information necessary for relatively rapid adjudications in Central Basin and San Gabriel Basin.

The second area of concern in the proposed legislation involved the authorization of a new type of district empowered to undertake broad replenishment responsibilities financed primarily by a "pump tax" or an assessment on the groundwater production within the boundaries of a district. The legislation as finally drafted was different from what producers in either West Basin or Central Basin might have drafted on their own.[36] By taking into account the needs of other areas and existing water service agencies, West Basin and Central Basin producers were able to gain rapid approval of both pieces of legislation when they were submitted to the state legislature in 1955.

The new Water Replenishment District Act authorized citizens located in southern California to create a new district after they had (1) obtained signatures from at least 10% of the registered voters residing within the boundaries of the proposed district, (2) proposed specific limits on the taxing power of the new district, (3) received agreement from the Department of Water Resources that the area included within the boundaries of the district would be benefited by inclusion, and (4) received a majority of positive votes in a special election held to consider the creation of the new district. A district, once created, was given a wide diversity of powers to raise revenue through a pump tax and, to a limited extent, through a property tax and to undertake actions to replenish a groundwater basin. The organic legislation included a unique provision intended "to avoid duplication of similar operations by existing agencies and replenishment district" (*California Water Code*, sec. 60231). The provision stated that

> in the event an existing agency has facilities available and adequate to accomplish any part of the purposes of a district . . . the district shall investigate and determine the cost of contracting for the accomplishment of such purposes through such existing agency. (*California Water Code*, sec. 60231)

In other words, a new replenishment agency would be expected to investigate the costs of contracting to have services provided, rather than immediately creating its own production staff for any activity it wanted to undertake.[37] The legislation provided a general "constitution" for a new district. Water producers in any specific area could then use that general framework to create a particular "constitution" for their own district. At first, West Basin producers presumed that they would go it alone and created a working committee within the association to draft a specific proposal to create a district.

The basic issues that had to be resolved in that constitutional process were (1) the source of water for the barrier, (2) the exact boundaries of the new district, (3) how the internal electoral boundaries would be drawn,

and (4) the extent of taxing powers to be authorized. West Basin water producers had hoped that it would be possible to purchase reclaimed water from the Hyperion water-treatment plant – a sewage-disposal facility operated by the city of Los Angeles – located on the coast. If that had proved technically feasible, they would have had a source of low-cost water and would not have had to negotiate with the powerful Metropolitan Water District of Southern California (MWD). After considerable experimentation, it proved technically infeasible to use the reclaimed water, at least in the short run. The committee had to start over again. Members of both associations were appointed "to approach the Metropolitan Water District . . . to see whether a firm commitment of a sufficient quantity of water could be obtained . . and to request a certain amount of engineering and costs estimates which would be needed" (report by Allan Harris, West Basin Water Association, minutes, March 22, 1956, p. 6).

Once West Basin producers realized that they would have to use MWD water for the barrier, they began more intensive talks with their Central Basin neighbors concerning the creation of one large district to include both basins. When the two associations first started discussions, the differences between the two basins were quite apparent. West Basin was smaller in area, population, and assessed valuation. In a joint district, it could be dominated by Central Basin. In 1955, West Basin producers had signed the interim agreement and had limited their production to 60,000 acre-feet per year, whereas Central Basin producers were pumping 110,000 acre-feet and still increasing their annual rates of withdrawal. At a meeting of the West Basin Water Association, the chairman of the committee devising the proposal outlined the reasons for and against forming a district to include both basins.

Reasons for forming a district to include both basins

1 The purpose would be the same in both basins: replenishment of the groundwater supply.
2 Greater financial resources would be available; hence, the tax rate and amount of pumping assessment could be lower.
3 A large district would have greater political strength and would be more effective in dealing with the Upper San Gabriel Valley District and various state bodies.
4 The Long Beach harbor area offers a potential route for intrusion of seawater into West Basin and probably would be included. It is doubtful that any of Long Beach could be included in a district comprising only the West Basin.

5 The flow of groundwater across the fault from Central Basin to West Basin probably would be greater under the replenishment program of a larger district.
6 Administration costs would be less in a larger district.

Reasons against forming a district to include both basins

1 The injection of replenishment water would be unique and necessary to West Basin. Central Basin would control that program in the West Basin if a large district were formed and might not want to continue the well-injection method along the coast.
2 Pumping was curtailed in West Basin, but not in Central Basin.
3 The degrees of ultimate curtailment might not be the same in the two basins.
4 Control of the local tax rate and amount of pumping assessment would be relinquished by West Basin.
5 A local district could initiate proceedings to ensure financial replenishment from Central Basin.[38]
6 Extensive recharge of Central Basin might contribute free water to West Basin (West Basin Water Association, minutes, November 17, 1955, pp. 9–10).

The West Basin water producers were physically disadvantaged because they were at the end of the groundwater "pipeline." They were concerned that their physical disadvantage could be exaggerated by the creation of a new public agency in which they would be politically dominated. The hopes and fears of West Basin producers were summarized in a letter written by the chairman of the West Basin committee to his committee:

> In the event a water replenishment district to include both Basins is decided upon, it appears desirable that a statement of policy morally binding on the new district board of directors should be adopted. The policy should provide assurance of an effective salt water barrier program for West Basin, a curtailment of pumping in Central Basin to insure continued ground water flow into West Basin, and an arrangement of the five divisions of the new district so that territory of both Basins would be included in each such division to prevent West Basin versus Central Basin representation on the board of directors.
>
> (letter from R. R. Thorburn to the Replenishment District Boundary Committee, October 27, 1955, p. 2)

Soon thereafter, members of both associations came to a working agreement that the benefits of a larger district would outweigh the costs. Assurances were given to West Basin producers that they would not be

dominated by their eastern neighbors. Next, a joint committee of both associations began a series of relatively tough negotiations with all of the public agencies that might eventually be involved in managing these two basins.[39]

The results of those negotiations were formalized in a seven-page proposal that the committee submitted to the two associations for approval in August of 1958. The proposal set forth the essential factors for constituting the new enterprise. The statement proposed that a new replenishment district would be formed to (1) repel saltwater intrusion, (2) recharge the groundwater basins, and (3) reduce pumping in the basins to safe limits (West Basin Water Association and Central Basin Water Association, "Proposal Submitted by the Joint Committee on Water Replenishment District," mimeograph, July 30, 1958, p. 1). The proposal stated that to accomplish those purposes, "the district will have responsibility for financing the purchase of water used in halting the intrusion of sea water and in replenishing the groundwater supply" (ibid., p. 3).

The proposal then clarified the future relationships of the replenishment district to all of the existing agencies that might consider the replenishment district to be a potential competitor. It then outlined the amount of water that would be purchased from MWD and spread or injected by the Los Angeles County Flood Control District. The proposal stated that the new district "would have no authority to purchase replenishment water with *ad valorem* tax derived funds, and the petition for the formation of the district will clearly set forth this limitation on its taxing power" (ibid., p. 6). It was estimated that a levy of $6.00 per acre-foot would be necessary to raise the necessary funds to purchase 165,000 acre-feet of water from MWD – an amount equal to the average annual overdraft. The proposal concluded by stating that the new district would be "an administrative agency operated by a five-member board of directors with a minimum staff" (ibid., p. 7).

The proposal was in effect a "constitution" for a multiple-agency management system to operate a coordinated program. Constitutional documents do not need to carry the formal name "constitution" to serve the purpose of determining the decision rules to be used for making future collective choices about some specified physical domain. The proposal was attached to the formal petitions presented to the Los Angeles County Board of Supervisors (to gain approval for the special election) and to the California Department of Water Resources (to gain approval for the boundaries), and in that way had formal recognition as a type of constitutional document. Once that constitution had been approved by the two private associations, all formal steps outlined within it were achieved within a few months, and the Central and West Basin Water Replenishment District was

supported in the election of November of 1959 by a vote of 4 to 1 (*Los Angeles Times*, November 18, 1959).

THE POLYCENTRIC PUBLIC-ENTERPRISE GAME

The creation of the Central and West Basin Water Replenishment District in 1959 dramatically transformed the structure of incentives facing water producers and their representatives. It was an enterprise created by the water producers (and approved by the citizens living in the area), with public powers to tax, to sue, and to engage in the provision of collective goods. Whereas the replenishment district took over the *active* role of managing West Basin and Central Basin, the two private water associations continued to have strong input into all policy decisions.

Further, the replenishment district is only one public enterprise among a half dozen agencies that are actively involved in the management program. Thus, instead of one central governmental authority, a polycentric public-enterprise system has emerged to achieve a very sophisticated management system. This polycentric system has restored water levels throughout both basins, has completed a freshwater barrier along the exposed coasts of both basins, and is now engaged in focused efforts to eliminate pumping troughs and other physical impediments that inhibit the effective use of the basins in conjunction with a surface supply.

The overall costs of this system are quite low.[40] In Table 4.1, the amortized and annual costs (in constant dollars) of the management systems in these basins, as computed by Blomquist, are contrasted with the amortized costs of replacing the basins with surface storage. Total costs are substantially lower in each basin than they would be if the basins had been destroyed. Total costs would, of course, be lower if water producers had been able to negotiate a settlement of their water rights at an earlier juncture and had not had to pay the high costs of prolonged negotiations. The water producers of Central Basin, however, learned from the experiences of their colleagues in Raymond Basin and West Basin and thus were able to achieve a settlement at lower costs.

In this discussion I have tried to focus more on the origins of these institutions than on their current operations, because it is so difficult to find documentation about the origins of institutions. I do think it is important, however, to describe briefly the types of polycentric relationships that exist among the public enterprises that currently manage West Basin and Central Basin.

At the core of each of those relationships is the Central and West Basin Water Replenishment District. This district receives the funds assessed on

Table 4.1. *Basin management costs and savings per acre-foot resulting from basin management in the three basins (dollars)*

Cost	Raymond	West	Central
Basin management cost per acre-foot of ground-water extraction, 1985	3.50	77.40	73.77
Average cost of an acre-foot of water with basin management	184.65	235.71	224.85
Estimated cost of an acre-foot of water if all groundwater were replaced by imported water	748.68	739.30	739.94

Source: Adapted from Blomquist (1987a, Figure 9).

all water pumped in the district and thus has the power to take collective action for both basins. To get the water into the basins, however, the replenishment district must relate to several other public districts. Until the late 1960s, the replenishment district depended on a monopoly supplier of water, the MWD, for its replenishment water. In 1966, MWD unilaterally announced a change in its pricing structure that would substantially increase the cost of replenishment water. The replenishsment district and both associations bargained hard, but unsuccessfully, for a reconsideration. The replenishment district then opened negotiations with the Los Angeles County Sanitation Districts to obtain a reliable supply of water at lower cost from a specially constructed reclamation plant.[41] Opening this alternative source of water supply has meant that the replenishment district has assured itself of a continuing supply, and at a cost well below that of imported water. In 1987, for example, the district was seeking approval from the relevant regulatory agencies to increase its purchase of reclaimed water from 30,000 acre-feet per year to 50,000 acre-feet per year, at an average cost of $8.00 per acre-foot, as compared with the $153 it has to pay MWD for replenishment water (Central and West Basin Water Replenishment District 1987, pp. 44–56).

In regard to the actual operation of the replenishment works, the replenishment district entered into an exchange agreement with the Los Angeles County Flood Control District (reorganized in 1987 to be the Los Angeles County Department of Public Works). Thus, the replenishment

district has maintained only a skeletal staff (an executive director and a secretary), rather than employing its own engineering staff. The county cannot exert full monopoly power in its supply of replenishment services, because the replenishment district has access to several other potential suppliers and could always create its own staff to undertake the replenishment activities.[42] At one point when the replenishment district was particularly unhappy with the progress of some construction work undertaken by the county, the replenishment district was able to use its bargaining power to insist that a portion of the design for one of the barriers be contracted out to a private firm.

The watermaster service of the California Department of Water Resources performs an essential service for the replenishment district and the producers by monitoring the extractions by producers. Two-thirds of the cost of this service is paid for by the producers. If these costs become too high, the producers can petition the court to assign some other agency – public or private – to be their watermaster.[43] The replenishment district and the watermaster service have entered into cooperative agreements to reduce duplication in their activities. Records of withdrawals submitted by groundwater users to the replenishment district as the basis for taxation are also made available to the watermaster. Instead of relying strictly on hierarchical relations, as within a single firm, the management system is governed by negotiation and bargaining processes among many different actors in several different arenas. Strict majority-rule procedures are rarely used in any of the decision arenas governing this system.

In addition to the public districts, private water associations remain active in each of the basins. Public officials are asked to make frequent reports to the regular meetings of the water associations. The water engineers of the private and municipal agencies who attend these meetings tend to ask tough questions and want reasoned answers. They have access to independent information about conditions and are not satisfied by stylized responses that provide little information. Many of the individuals who are elected to office in the public districts have been active in the water associations for many years. Their tenure in public office tends to be long, and normally they are active in one or another public or private role for a quarter of a century.

This brief sketch of the patterns of relationships among public enterprises illustrates how a governance system can evolve to remain largely *in* the public sector without being a central regulator. Aspects of both private and governmental activities are involved in all of these basins. Some scholars have characterized the assignment of well-defined rights to the flow of a

CPR as "privatization." Given that the water rights held by water producers are now entirely separable from land and are well defined, a market for water rights has evolved in each of these basins, and rights are actively transferred. But that is only part of the story. No one "owns" the basins themselves. The basins are managed by a *polycentric set* of limited-purpose governmental enterprises whose governance includes active participation by private water companies and voluntary producer associations. This system is neither centrally owned nor centrally regulated.

Although the solution to the problems facing these groundwater producers did not involve either a central regulator or a private-property system, it did involve creating an institutional arrangement that incorporates the full set of design principles discussed in Chapter 3. Well-defined boundaries were achieved through litigation. Viewing this set of institutions together,[44] it can be seen that congruence between appropriation and provision rules and local conditions has been achieved. Collective-choice arrangements are provided by the voluntary associations and by the special districts so that most pumpers can actively participate in the modification of rules as needed. The court-appointed watermaster has considerable monitoring powers and issues annual reports that give all participants accurate information about rule compliance and water conditions. The informal sanctions that have been utilized to encourage rule conformance have, in the main, been modest. Formal sanctions are available for use if they are needed. The continuing jurisdiction of the court and the regular meetings of the voluntary water associations provide conflict-resolution mechanisms. The legal structure of the state of California recognizes the rights of pumpers and others to organize, and the organization units are nested within larger units. Given the stability that these institutions have demonstrated thus far, and their conformance with these design principles, I believe that these CPR institutions are robust and will survive for a long time to come.

THE ANALYSIS OF INSTITUTIONAL SUPPLY

In this chapter I have described several efforts to solve second-order collective dilemmas. A pumping race is the first-order dilemma facing pumpers from a groundwater basin where legal rights to withdraw water are not limited. Each pumper has a dominant strategy to pump as much water as is privately profitable and to ignore the long-term consequences on water levels and quality. The experience in all of these groundwater basins illustrates how a pumping race can continue for many years, even though water levels fall (raising everyone's costs of lifting water) and salt water intrudes

(threatening the long-run survival of the basin itself). Overdraft conditions continued for several decades in these basins. The best explanation for the actions and outcomes during that period is that individuals caught in a pumping race will select their dominant strategy to pump as much as is privately profitable and ignore the consequence for themselves and others.

Given the initial empirical support for this prediction, it is easy to see why theorists would also predict that individuals caught in such situations would refrain from investing resources in designing, negotiating, and supplying new institutions. If pumpers will not limit their groundwater production, why should they invest in the provision of new institutions? The effort to supply institutions is described as simply a second-order dilemma that is no more solvable than the first-order dilemma. The prediction that appropriators will not expend resources to supply new institutions is, however, not supported by these case studies.

These groundwater pumpers invested heavily in the supply of institutions. They created new private associations. They paid for costly litigation to allocate water rights. They drafted legislation, had it introduced to the state legislature, and gained sufficient support from other water enterprises to get the legislation passed. They created special districts to tax all the water they withdrew from the basins, as well as the property overlying the area. They spent seemingly endless hours informing themselves about the structures of their basins, the various concerns and intentions of all parties, and future possibilities.

Incremental, sequential, and self-transforming institutional change in a facilitative political regime

The substantial investments that these groundwater pumpers made in providing new institutions occurred in an incremental and sequential process in the state of California – a home-rule state – where many statewide institutional facilities are provided to reduce the costs of local institutional supply. The investment in institutional change was not made in a single step. Rather, the process of institutional change in all basins involved many small steps that had low initial costs. Rarely was it necessary for participants to move simultaneously without knowing what others were doing. Because the process was incremental and sequential and early successes were achieved, intermediate benefits from the initial investments were realized before anyone needed to make larger investments. Each institutional change transformed the structure of incentives within which future strategic decisions would be made.

Further, because the appropriators from several neighboring basins were

all involved in similar problems, participants in one setting could learn from the experiences of those in similar settings. Sufficient overlap existed among participants across basins to ensure communication about results. Interbasin coordinating arenas were created at several junctures to enhance the ability to exchange information about agreements reached within and across basin boundaries.[45]

In each basin, a voluntary association was established to provide a forum for face-to-face discussions about joint problems and potential joint strategies. Given the uncertain legal structure, attorneys advising water companies and public utilities had consistently advised their clients to pump as much water as they could profitably use and worry about defending their water rights later. The provision of a forum for discussion transformed the structure of the situation from one in which decisions were made independently without knowing what others were doing to a situation in which individuals discussed their options with one another. Discussion by itself was not sufficient to change the pumping strategies of the participants, but discussion did lead to the initiation of litigation, which enabled the participants to reach an enforceable agreement to limit their water withdrawals.

Further, the voluntary associations provided a mechanism for obtaining information about the physical structure of the basins to be made available to all pumpers simultaneously. Prior to that investment in information, no one had a clear picture of the boundaries, demand patterns, and water levels throughout a basin. One knew only that the water levels in one's own wells were falling. No one knew the extent of saltwater intrusion or the total quantity of water withdrawn from the basin. The private associations provided a mechanism for sharing the costs and the results of expensive technical studies. By voluntarily sharing the costs of providing information – a public good – participants learned that it was possible to accomplish some joint objectives by voluntary, cooperative action. The membership dues for the associations were modest and were allocated in rough proportion to the amount of water an enterprise withdrew from a basin.[46] By spending time to attend meetings, members gained considerable information about the condition of their basins and the likelihood that others would commit themselves to follow different strategies in the future.

Whereas the voluntary associations provide a mechanism for sharing costs, the state of California provides facilities that help reduce the level of those costs. Maintaining a court system in which individuals have standing to initiate litigation in order to develop firm and transferable rights to a defined quantity of water is one such contribution. The state of California goes even further and subsidizes one-third of the cost of such litigation in

order to encourage full exploitation of water resources and settle disputes over water rights when necessary. The Department of Water Resources has provided technical assistance throughout the period, as has the U.S. Geological Survey.

The general home-rule tradition that is built into the state constitution and legislative practices in the state also helps reduce the costs of transforming existing rule systems. It is relatively easy for a group of individuals to introduce new organic legislation authorizing a new type of special district, but state legislators will rarely support such proposed legislation when there is substantial opposition to it in the state. But when individuals in one area have discussed such proposals with others who are likely to be affected, organic laws frequently are passed with close to unanimous support.

In other words, the rules for engaging in microconstitutional choice related to the control of groundwater have encouraged investments in self-organization and the supply of local institutions. A similar set of individuals facing similar problems in an entirely different type of political regime might not be able to supply themselves with transformed microinstitutions. The difference between an active effort by a central government to regulate appropriation and provision activities and an effort to provide arenas and rules for microinstitutional change is frequently blurred.

Reformulating the analysis of institutional change

Trying to understand the incremental, sequential, and self-transforming process of institutional change in these groundwater basins leads me to suggest that institutional analysts should reconsider the ways in which they conceptualize the problem of supplying institutions. Such a formulation should involve several subtle but important changes in the way analysts think about institutional rules, their origin, and their changes. An important step is to assume that all recurring situations are shaped by a set of institutional rules. Institutional rules are prescriptive statements that forbid, require, or permit some action or outcome (E. Ostrom 1986a). One of the three deontic operators – forbid, require, permit – must be contained in a statement for it to be considered a rule.[47] All three deontic operators are used in this definition of rules.[48]

Some analysts limit their conception of rules to prescriptive statements containing only required or forbidden actions and outcomes.[49] With that limited conception, some recurring situations are rule-governed, and others are not. By including all three deontic operators in a definition of a rule, it is always possible to identify the set of rules that constitute a situation.

One needs to ask only two questions concerning the actions and outcomes of relevance to this situation: (1) Is this action or outcome (or its negation) required? (2) Is this action or outcome (or its negation) forbidden? Any action or outcome (or its negation) that is not required nor forbidden is permitted. Consequently, the absence of a rule forbidding or requiring an action is logically equivalent to the presence of a rule that permits an action. Hobbes's state of nature is a situation in which no rules requiring or forbidding any actions or outcomes are present. The Hobbesian state of nature is logically equivalent to a situation in which rules exist permitting anyone to take any and all desired actions, regardless of the effects on others.

Usually it is possible to answer the two foregoing questions regarding any recurring situation that is sufficiently structured that one can analyze it. Consequently, for any such situation, one can identify a set of status quo rules related to the situation. Status quo rules continue in effect until changed. The status quo rules in a Hobbesian situation can be viewed as a set of default rules by which everything is permitted (Gardner and E. Ostrom 1990). Similarly, a CPR situation in which no one is forbidden or required to take any action is logically equivalent to a CPR situation in which everyone is permitted to take any and all actions. The rules governing such a situation are all default rules.

Once one assumes that all recurring situations are characterized by a set of status quo rules, then it is possible to broaden the concept of institutional supply to include both what can be called the "origin" of new institutions and the changing of existing institutions. The origins of institutions and changes in institutions frequently are considered to be fundamentally different.[50] In this view, origin is characterized as a situation in which individuals move from having no rules to having a set of rules. In such a view, the origin of institutions is thought of as a major, one-step transformation, whereas institutional change is viewed as involving incremental changes in existing rules.[51] Supplying new institutions is consequently viewed as nonincremental and costly, whereas changing existing institutions is viewed as incremental and not as costly.

Both origins and changes in institutions can be analyzed using the same theory when both are viewed as alterations of at least one status quo rule.[52] A change in any rule affecting the set of participants, the set of strategies available to participants, the control they have over outcomes, the information they have, or the payoffs (E. Ostrom 1986a) is an institutional change. The costs of changing the rules vary substantially from one rule to another, from one political regime to another, and from one level of analysis to another, and they also vary over time as participants and conditions

change. Whether or not it will be costly to achieve any institutional change will depend on many variables (to be discussed in Chapter 6), not simply on whether or not a new institutional arrangement is being created.

The creation of a new institutional arrangement can sometimes be quite easy and involve little cost. In the cases discussed earlier, for example, creating new voluntary associations to discuss common problems did not involve major investments by any of the participants. On the other hand, creating the Central and West Basin Water Replenishment District involved major investments in time and money. Transforming existing rules can also be very costly. Changing the water rights for overlying and appropriative water producers, for example, involved many years of costly litigation. All of these rule changes were crucial aspects of the process of institutional supply in these cases. Each built on the base of prior rules. That some rule changes could be undertaken with low transformation costs enabled the participants to gain some advantages of collective action before they were faced with more costly alternatives. All of these transformation costs are affected by the surrounding political regime. After several decades of institutional change, the resulting institutional infrastructure that had been created represented a major investment that dramatically changed the incentives and behaviors of participants and the resulting outcomes. Each institutional change became the foundation for the next change.

What is presumed to be a second-order dilemma, in which institutional change is viewed as one large step, may or may not have the structure of a dilemma when institutional change is viewed as a sequential and incremental process. The net payoffs of solving a small part of a large second- or third-order problem may be sufficiently high and distributed in such a manner that some participants will voluntarily provide initial second-order collective benefits, whereas they are unwilling to provide first-order solutions on their own. Solving some initial second-and third-order problems can help participants move toward solving first-order problems, as well as the more difficult second- and third-order problems.

With these conceptual revisions, it is possible to move toward the development of a single theory of institutional change, rather than one theory about origins and another theory about reform. Both constitutional-choice and collective-choice processes produce rules affecting the behavior of actors in linked situations (see Figure 2.2). Both constitutional-choice and collective-choice processes are themselves structured by rules. In a constitutional-choice situation, individuals decide whether or not to change a set of status quo rules that determine who is eligible and how future collective-choice decisions are to be made. Similarly, in a collective-choice situation, individuals decide whether or not to change a set of status quo

rules that determine who is eligible and how future operational choices are to be made.

The outcome of a collective-choice process frequently is conceptualized as a "policy space," leaving unspecified what is contained in that policy space. When a budget is to be determined in a collective-choice arena, the policy space can be thought of as a set of rules concerning who is required, forbidden, or allowed to spend how much money for what purpose during what time frame. When a regulation is to be determined, the policy space can be thought of as a set of rules concerning who is required, forbidden, or allowed to take what action or affect what outcomes related to a specific domain.

In both processes, individuals compare the net flows of expected benefits and costs to be produced by the set of status quo rules, as compared with an altered set of rules. To explain institutional change, it is therefore necessary to examine how those participating in the arenas in which rule changes are proposed will view and weight the net return of staying with the status quo rules versus some type of change. In Chapter 6, I shall develop these ideas further and present the rudiments of a theory of institutional change applicable to the changing of rules that structure collective-choice or operational-choice situations. Before I do that, however, it is important to examine the failure cases discussed in Chapter 5 so that these conjectures can also build on information from situations in which participants were not successful in changing their institutions.

5

Analyzing institutional failures and fragilities

The empirical cases presented so far have been success stories. Given the presumption of failure that characterizes so much of the policy literature, it is important to present examples of success. Now the time has come to examine several cases of outright failure and cases in which the institutions designed by appropriators are in a fragile condition.

Near Alanya, Turkey, where fishers were able to establish their own set of rules for regulating inshore fisheries, there are two other fishing areas whose fishers have failed to establish effective rule systems – Bodrum and the Bay of Izmir. Both suffer severe problems of overcrowding and rent dissipation. In San Bernardino County, California, groundwater pumpers are still facing overdraft conditions even after they initiated litigation and created a special district. The institutional arrangements described in Chapter 4 that helped nearby basins solve CPR problems did not work as effectively when applied to a region rather than to a basin.

In another part of the world, Sri Lankan fishers, who had devised an ingenious system for rotating access to an inshore fishery, found themselves unable to enforce an additional rule to prevent the entry of new appropriators. The rotation system continues to spread the risk involved in an uncertain environment across all participants. With too many appropriators, however, the profits obtained by local fishers have steadily declined as rents have been dissipated.[1]

In the interior of Sri Lanka, central-government authorities and donor countries have invested large sums in the reconstruction of major irrigation systems. To work successfully, these systems need the active cooperation of the farmers to schedule and manage water use so as to minimize wastage. National officials have altered the administrative structures of these systems several times without succeeding in obtaining farmer cooperation in

implementing rules to allocate water to minimize overuse. The Sri Lankan experience with the reluctance of farmers to invest time and effort to enhance the productivity of a centrally managed system has been repeated in many diverse forms throughout South and Southeast Asia. In some cases, centralized efforts to reform the structure of a system have led to worse problems. However, an experimental project to organize farmers from the ground up, without an organizational blueprint, has produced a reversal of that problem in one large Sri Lankan irrigation system.

The last case to be considered, not yet a failure, is an instance of locally developed rules to regulate access and use of an inshore fishery, but they are not recognized as legitimate or effective by national authorities. In both Nova Scotia and Newfoundland, many local villages have devised their own rules to determine who can use local fisheries and how resources are to be harvested. Recently, the Canadian national government has taken a more active role in fishery regulation along its eastern coast. The national government is attempting to develop uniform policies for the entire coast. There are, however, two quite different types of fisheries on this coast: (1) the deep-sea fisheries, which are open-access CPRs, and (2) the inshore fisheries, in which local fishers have established informal rules controlling access and use. The need for a large-scale governmental agency that can restrict access to the deep-sea fishery is well established. But the unwillingness of the national authorities to develop a nested system of rules, drawing on the experience of many generations of fishers who intimately know their own fisheries, may destroy one set of effective CPR institutions without necessarily developing effective alternatives.

TWO TURKISH INSHORE FISHERIES WITH CONTINUING CPR PROBLEMS

Bodrum is located about 400 kilometers west of Alanya on the Aegean Sea. The number of fishers appropriating from the Bodrum fishery is substantially larger than the number of fishers in Alanya. In the Bodrum fishery in 1983, there were 100 small boats with inboard power, 11 trawlers, 2 purse seiners, and 9 bottom seiners, operated by approximately 400 fishers (Berkes 1986b, p. 68). Until the 1970s, Bodrum had been the site of a successful inshore fishery. Fikret Berkes reports that in the 1970s the government of Turkey had encouraged some Bodrum fishers to construct larger trawling vessels and "had rarely enforced the three-mile limit, much to the anger of the small fishermen" (Berkes 1986b, p. 79).[2]

The early financial success of the trawlers lured others to enter the local fishery, until the revenues from the fleet as a whole were less than the costs

of fishing in the area. As Berkes indicates, Bodrum was a "textbook example of rent dissipation in a fishery" (1986b, p. 79). Although the total annual yield of fish remained approximately the same, the catch per unit of effort sharply declined. The larger vessels operating out of Bodrum could no longer make a living there and began to travel to the shrimp grounds near Mersin. A booming tourist trade lured many part-time fishers and charter fishing boats into the fishery.

A local fishing cooperative struggled unsuccessfully during the 1970s to mediate the conflicts among the small-boat fishers, the new entrants, and the trawlers. That cooperative had disappeared by 1983. Six groups of fishers with distinct interests now compete to appropriate from the same fishery:

> (1) small-scale coastal fishermen, (2) larger-scale operators including trawlers and beachseiners, (3) semiprofessionals who obtain their own fish and sell the occasional surplus, (4) large numbers of unskilled sport fishermen, (5) spear-fishermen licensed as sponge fishermen but who sell fish on the open market, and (6) charter boat operators who fish to feed their clients and occasionally sell the surplus.
> (Berkes, 1986b, p. 74)

A similar problem exists in the larger fishery of the Bay of Izmir, located farther north on the Aegean coast. In 1983, 1,800 fishers lived in the area and used 700 small boats with inboard power, 30 bottom seiners, and 27 purse seiners. The subgroup structure seen in Bodrum is similar to that in Izmir, where it is complicated by the fact that Izmir is a large urban center (a metropolitan area with a population of over 1 million) with a high demand for fresh fish. The result is an overcapitalized fishery, with too many fishers chasing too few fish.

The trawlers were not the problem in Izmir. It is difficult for trawlers to operate in such a crowded environment, and the Turkish coast guard actively patrols a major harbor. This CPR problem has been produced by a number of factors: the opportunities for quick economic gain, the large number of fishers, the internal division of the fishers into distinct subgroups with conflicting interests, and the lack of an overarching institutional mechanism in which local rules and conflict-resolution mechanisms could be designed. Two large fishing cooperatives are based at Izmir, but they represent distinct subgroups of fishers. Several other fishing cooperatives operate nearby, but also represent distinct subgroups. Each group had conflicts "with at least one other group, and in some instances, with more than one." Consequently, there were "no operational rules in place to allocate the fish, to reduce the conflicts, or to limit crowding" (Berkes 1986b, p. 75).

The general institutional setting within Turkey could be called "benign

neglect." National legislation required fishers to be licensed, but did not limit the number of licenses. Restrictions were placed on fishing during the spawning season and on the equipment that could be used. An effort had been made to segregate inshore fisheries from offshore fisheries by forbidding trawlers to fish within a three-mile offshore zone and within bays. The agency responsible for fishery rules (the Ministry of Agriculture) employed no agents to enforce those rules. The coast guard, the rural police, and the Ministry of the Interior were supposed to enforce the rules. Nonenforcement of the three-mile zone (other than in the large bays) and the financing and encouragement of new trawlers were thus sources of the failure in Bodrum.

The failure of the fishers in the Bay of Izmir and Bodrum to organize themselves to prevent rent dissipation cannot be attributed to a single cause. Internally, these were large groups that were characterized by severe heterogeneity of interests and of relevant time horizons. Given the different technologies in use, any rules that were defined to limit use would tend to benefit one subgroup over another, rather than benefit all in a similar manner. The costs of overcoming size differences and heterogeneity are substantial. In a political regime that does not provide arenas in which low-cost, enforceable agreements can be reached, it is very difficult to meet the potentially high costs of self-organization.

CALIFORNIA GROUNDWATER BASINS WITH CONTINUING CPR PROBLEMS

Although the groundwater pumpers in most of southern California have resolved their conflicts over limited water supplies and have protected their groundwater basins against continuing overdraft conditions, that experience has not been universal. The groundwater basins located in San Bernardino County, northeast of the basins described in Chapter 4, continue in overdraft condition, even though efforts have been made to allocate water rights through litigation and the creation of water districts. Why is it that individuals who have adopted strategies of institutional change that appear to be quite similar to those described in Chapter 4 have not succeeded in devising a workable set of institutional arrangements to manage their basins?

Obvious differences have to do with size and complexity. San Bernardino is the largest county in the United States, and there are nine states that are not as large as San Bernardino County. The combined areas of New Jersey, Hawaii, Connecticut, Delaware, and Rhode Island would fit into this one county (Blomquist 1989, p. 2). Approximately 83% of the county

is part of the Mojave Desert. Fifteen different groundwater basins – some interconnected and some totally independent – underlie the area. Some of these basins are fed by the Mojave River, which flows largely underground through a substantial portion of the county. Other basins are replenished only by local precipitation. The region was sparsely populated before World War II, but its population has grown dramatically in the postwar era.

Overdraft conditions were reported in some of the basins during the 1950s. During the late 1950s, the California Department of Water Resources began to plan the Feather River Project to bring water from the water-rich northern region of the state to the water-poor southern region. Areas desiring this water were encouraged to form water agencies in order to contract with the state for future deliveries of this water. The Mojave Water Agency was created, first by state law, and then by a special election in 1960, in order to levy a land tax to pay its share of the capital costs of constructing the aqueduct. After helping to pay for construction of the aqueduct, residents living in the area served by the Mojave Water Agency would eventually be able to claim 50,800 acre-feet of imported surface water per year, provided they paid for the marginal costs of a delivery system and the water itself.

Some of those who had been involved in establishing the Mojave Water Agency thought of it as a water wholesaler, similar to the Metropolitan Water District of Southern California, and as an insurance strategy for a growing area that lacked a local water supply. As a wholesaler, the agency could play an important role in obtaining water for the region, but not in managing the many hydrologic subareas of this vast terrain. As an insurance strategy, the primary activity of the agency would be to collect taxes to ensure that the area would eventually be entitled to a flow of imported water. If that view had predominated, the next steps after the creation of the Mojave Water Agency would have been the development of a diversity of smaller-scale private and public enterprises to resolve water-rights issues, devise management plans within subareas, and develop a polycentric system similar to the one that emerged in Los Angeles County.

Others saw the agency as the primary water-management institution for the entire area. That group included most of the officials who were initially elected to serve on the agency's council. Within a short time of its formation, the agency hired a distinguished water-rights attorney, James Krieger, who had been involved in the West Basin and Central Basin litigations, to initiate legal action to settle water rights for the entire region. In 1966, when litigation was initiated in the Superior Court of San Bernardino County, no consensus had developed concerning several key issues:

1 Could the region best be described as one region with a single underground river, as a series of interconnected groundwater basins, or as some combination of a river system, interconnected groundwater basins, and independent groundwater basins?
2 Were all parts of the region, or only localized areas, suffering from overdraft problems?
3 Should all groundwater pumpers be treated as coequal in status, or did some pumpers have prior rights that should be given preferential treatment?
4 Should an administrative settlement be worked out by the agency staff working primarily with the larger pumpers, most of whom were located in the upper reaches of the area, or should it involve the vast number of small pumpers, most of whom were located in the lower portions of the area?
5 Should water rights be separated from land ownership in a region that had not yet been developed?

Coherent arguments could be advanced for the opposing positions on each of these issues. Krieger and the staff members of the Mojave Water Agency, however, approached the situation as if there were only one legitimate answer to each of those questions. They viewed the entire region as if it were a single underground basin with a well-documented history of overdraft conditions. They treated all groundwater pumpers as having coequal rights and attempted to reach a stipulated settlement – to separate water rights from the land as rapidly as possible – with those who had been pumping 500 acre-feet or more per year. Their view of the issues, however, was not widely shared. In 1964, for example, the California Department of Water Resources published a report that denied the existence of overdraft conditions in two of the large subbasins included within the region under adjudication. On the other hand, the Mojave Water Agency had declared in the same year that overdraft of the Mojave River basins was an "unquestionable fact" (Blomquist 1989, pp. 63, 113).

No voluntary water associations were created to facilitate discussion of these issues, and no consensus emerged over time about any of them. Conflicts emerged between the large and small water pumpers, between advocates for development and advocates for no-growth policies, between industry and agriculture, between locals and "external experts," and between appointed personnel and elected officials. The lack of fundamental agreement led to acrimonious political conflict, including several recall elections, front-page stories in the local papers that pushed aside stories on the Watergate scandal, and finally the suspension of the litigation in 1974

(Blomquist 1989, pp. 57–77). No action has since been taken to limit groundwater pumping.

During the past decade the region has undergone massive development, and overdraft conditions have now been documented by all agencies. No one has yet found an effective means for resolving the problem of water-rights allocation or even the problem of purchasing surface-water supplies. The 50,800 acre-feet of Feather River water to which the Mojave Water Agency is entitled flows by each year to be used by others in the southern California region who have organized themselves to purchase water for immediate use or to store as part of a groundwater-management plan. No one has yet found an acceptable plan for building a distribution system and a means of financing that would enable residents of this area to pay for the marginal costs of obtaining the water to which they have an entitlement.

Attempts to solve the difficult problems of this large and complex region primarily on a regional scale using one instrumentality did not enable those involved to devise effective institutional arrangements to address the diverse problems they faced. Unlike the larger-scale fisheries in Bodrum and the Bay of Izmir, individuals in the Mojave area were able to initiate major changes in institutional arrangements. The changes they made, however, did not give them effective tools for dealing simultaneously with the diversity of problems involved. Even when individuals have considerable capabilities to engage in self-governance, there is no guarantee that solutions to all problems will be achieved. Individuals who do not have similar images of the problems they face, who do not work out mechanisms to disaggregate complex problems into subparts, and who do not recognize the legitimacy of diverse interests are unlikely to solve their problems even when the institutional means to do so are available to them.[3]

A SRI LANKAN FISHERY

At the southern tip of Sri Lanka lies the fishing village of Mawelle, as described by Paul Alexander (1977, 1982). Approximately 300 Sinhalese fishers live in the village and engage in three distinct types of fishing technologies: (1) large beach seines used to catch shoals of anchovies and similar species, (2) small traditional craft that use "bible" nets and fishing lines to obtain anchovies, squid, and rockfish, and (3) deep-sea fishing for tuna off the continental shelf. Most of the fishers in Mawelle come from the Karave caste[4] and are beach-seiners. We shall focus on this aspect of the local fishery.

Beach seines (called *madella* or "big net") are half-mile-long nets that may harvest a ton of fish at one time during the prime period when many

fish are available. The peak period occurs sometime during September or October and can constitute as much as one-third of the catch for an entire year (Alexander 1982, p. 134). A beach seine lasts for about five years before it must be replaced, at a cost of about three times the average household's annual income. Beach seines can be used only on beaches with relatively hard sand. On the Mawelle beach, there is room for only two nets to be used simultaneously. If the Mawelle fishers owned only 20 to 30 nets, they could make optimal use of most of their nets;[5] however, they own 100 beach seines, and the average net was in use only seven times during 1971 – strong evidence of severe overcapitalization.

Mawelle is another classic case of rent dissipation. This case has, however, an important twist. Whereas the fishers in Bodrum and the Bay of Izmir were unable to develop any effective rules to limit entry or the use of their local fishery, the fishers in Mawelle had devised quite elaborate rules regulating access to the beach and the use of the beach seines, but they were not able to sustain an entry rule controlling the number of nets to be used. When some of the fishers tried to get officials to enforce a provision in the national legislation that limited the number of nets to be used, others were able to convince national public officials not to enforce that provision. But before we discuss this problem concerning the enforcement of entry rules, let us examine the system of appropriation rules that Mawelle fishers had devised.

The appropriation rules in operation in Mawelle involve naming all the nets and placing them into a sequence. Each net owner is aware of the sequence of nets immediately preceding and following his net. The beach is divided into two launching sites, one on the harbor side and one on the rock side (Figure 5.1). A net may first be deployed on the harbor side anytime during the day after the net preceding it has been used. As illustrated on Table 5.1, once a net has worked its way up in the sequence so as to have had a dawn run on the harbor side, the net is next eligible for the dawn run on the rock side. "Subsequently, it may be used on the rock side at any time of the day once the net immediately following it in the sequence has been used" (Alexander 1982, p. 145).

The Mawelle fishers provide a coherent explanation for why they use this complex set of authority rules, rather than a simple rotation system, to equalize the opportunity to make a big catch. Four environmental or technological considerations affect the problem of equalizing access: (1) The harbor side produces the really big catches, but the rock side is more consistently productive when there are fewer fish. (2) The first catch of the morning is most likely to be the biggest catch of the day, and prices are highest in the morning. (3) The weather affects the number of hauls that

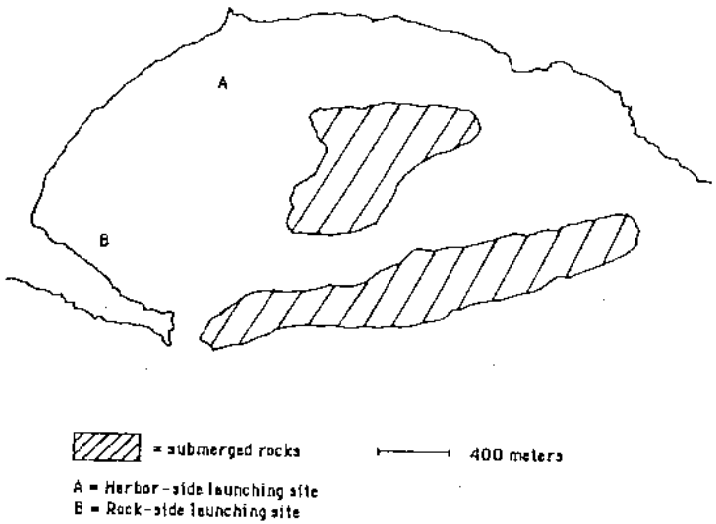

Figure 5.1. Harbor at Mawelle. (Adapted from Alexander 1982, p. 17.)

Table 5.1. *Net sequencing at Mawelle*

Day of week	Harbor side				Rock side			
	Dawn →				Dawn →			
Monday	B	C	D	E	A	Z	Y	X
Tuesday	C	D	E	F	B	A	Z	Y
Wednesday	D	E	F	G	C	B	A	Z
Thursday	E	F	G	H	D	C	B	A
Friday	F	G	H	I	E	D	C	B

Note: This is a stylized representation of how the first four nets (using letters of the alphabet to symbolize a net) would be launched daily at each site, based on Table 7.1 of Alexander (1982). In practice, the number of nets in use varies from day to day, and the same number of nets may not be launched from both sites.

can be made in a day, and any system assigning a set hour of the day would be inefficient. (4) Beach-seining involves high labor inputs to prepare a net for use and to restack it afterward, and simple rotation systems allowing all nets to be used only once per rotation would involve higher labor costs (Alexander 1982, p. 146).

Disputes about this sequencing are rare, except when the rules themselves are challenged, as described later. During the two years that Alexander spent in Mawelle, he never observed a dispute about the sequence in which nets would be beached. The absence of conflict over the authority rules in the fishery contrasts sharply with that society's high levels of violence, in Mawelle as well as similar fishing villages. During Alexander's stay, "three men were murdered and seventeen other assaults resulted in serious injuries" (Alexander 1982, p. 8).

The rotation system evolved in an era in which the number of nets varied around 20. With that number of nets, the system produced relatively equal and profitable incomes for all net owners. Because nets were so expensive and because at least eight men were needed to haul in a net, a net was divided into eight ownership shares. Until recent times, each owner did his share of the work, and they divided the value of the net's haul equally. Shares were bought and sold among village residents:

> Shares may be freely bought, sold, and used as security for various forms of mortgage. In former years they were often the most valuable item inherited, and, less frequently, were included in dowry payments. Although shares are freely transferable, in the sense that the other shareholders in the net do not have a legal veto over a prospective sale, the other shareholders do have a strong practical veto. Shareholders must work closely together and few men would buy a share in a net where the other shareholders strongly objected to the sale.
>
> (Alexander 1982, p. 143)

Until the late 1930s, fishing in Mawelle was largely for subsistence and to produce dried fish for a winter market. The returns from selling dried fish were relatively low. But demographic pressure, market opportunities, and the relationship between internal rules and external rules together changed that situation markedly.

The population of Mawelle grew by 70% between 1901 and 1931, with a disproportionate amount of the growth occurring among beach-seining families (Alexander 1982, p. 204). That disproportionate growth was due to an earlier labor shortage that had led the heads of beach-seining families to encourage their sons-in-law to live in Mawelle and invest in one of the eight shares of a family net. By 1931, the second generation of this in-migration began to marry and wanted access to the harvest. Given that access was tied to the eight-share system, sons had great motivation to

attempt to acquire a share in a new net. Alexander illustrates the logic of the situation clearly:

> If there are twenty nets, a man with one share will receive 1/160th of the annual catch. But if after his death his two sons take joint ownership of his share, they each receive only 1/320th of the catch, whereas if one joins in the construction of a new net they each receive 1/168th. (Alexander 1982, p. 204)

In 1933, legislation was enacted requiring the registration of beach-seines throughout the country. Along the southern coast, where share systems were the dominant forms of ownership, the "government limited the number of nets at any site to those in use in 1933 and codified the criteria for allocating access to the water" (Alexander 1982, p. 206). Thirty-two nets were registered in 1933. The registry reveals that almost all fishers owned a single share in one net. The legislation allowed individuals who did not inherit access rights to the fishery to purchase shares in established nets. That opened access to the fishery to persons outside the limited number of families that previously had shared access to the use of beach seines on the Mawelle beach. Opening access outside the original kinship groups would not have affected the number of nets competing for access if the provision limiting the number of nets to the number in use in 1933 had been enforced. Unfortunately, the limit on nets was not enforced, as we shall see.

During the early 1940s, the construction of a new road linking Mawelle to marketing centers, the construction of an ice factory nearby, and the marketing efforts of the Fish Sales Union greatly increased the demand for and market value of fresh fish. Prices for fish increased fourfold between 1938 and 1941 (Alexander 1982, p. 210). Then the pressure to introduce new nets really gained momentum. By 1945, 71 nets were in operation. At first, the operation of that many nets was highly profitable, even though the marginal product of each additional share was negative.[6] The average price of a share had risen substantially from 1935 to 1945 and was to continue to rise for another two decades, before dropping to a lower level again (Alexander 1982, p. 227).

New entrepreneurs began to buy shares in more than one net and to hire wage laborers to work their shares. By purchasing shares in nets well separated in the sequence, profitable returns could be made during each year. On the other hand, a poor fisher, who owned only a single share, received a profit only in those years when his net operated during the limited flush season. In earlier times, everyone had operated a net during the high-yield season. By 1971, however, that occurred, on the average, every three years. In the other two years, the income earned from a single

share was less than a subsistence-level income. Poorer owners of single shares began to sell their shares to others. A fisher who owned one share in each of five nets appropriately spaced throughout the sequence could make a modest profit each year, but he would have to make a substantial capital investment to spread his risk appropriately. Alexander computed the optimal number of shares for a person who intends to work his own shares to be 6.5 shares. In 1971, 95 of the fishers (58%) owned 5 shares or less.

Thus, the ownership patterns were shifting at the same time that the number of nets was greatly increasing. In the earlier system, those who owned shares had been long-term residents of the village, had belonged to the same kinship group, had owned only a single share each, and had worked that share. By 1971, many of the owners were not members of the same kinship group, owned shares in multiple nets, and hired wage laborers to work their shares. Further, the heads of several factions in the village purchased shares both for the economic return they could obtain and as a means of providing work for their loyal followers.

During that time, several efforts had been made to enforce the net-limiting provision in the 1933 legislation. After petitions had been submitted to the government agent in Hambantota in 1940, 1942, and 1945, a petition submitted in 1946 was accepted by the government agent, who agreed that the number of nets to be used in the future would be limited to the 77 nets then registered (Alexander 1982, p. 213). The 1946 petition was supported not only by the fishers who owned single shares and had actively supported the earlier efforts but also by the three largest shareholders in the village, who had earlier opposed such restrictions.

The government agent's decision substantially slowed, but did not completely stop, the construction of new nets. Entrepreneurs who offered sufficient inducements to government authorities were able to add a new net from time to time. Seven new nets were added in the next two decades, as compared with the 39 nets that had been added in the prior decade. That temporary brake on new entrants was to be completely destroyed in 1964 by the entry of a new entrepreneur – David Mahattea – into beach-seining. Finding it difficult to buy shares in current nets, Mahattea approached the local member of parliament (MP), a member of the Sri Lankan Freedom Party, and argued for permission to construct additional nets. The MP asked the district revenue officer to consider the proposal. The district revenue officer refused at first, arguing that there were too many nets. When the day came for the annual registering of nets, four members of Mahattea's faction appeared with nets borrowed from a nearby village. After considerable conflict in the village, the district revenue officer or-

dered those nets to be registered. Further nets were added when another faction leader supported a candidate from the opposition party and he won at the next election, after agreeing that additional nets could be registered in 1965. Between the two faction leaders, 24 new nets were constructed and added to the 84 nets then in operation.

At first, the other fishers were successful in excluding these new nets by devising a well-planned maneuver. The objective was to preclude the launching of the newly registered net 85. Once that net was launched, 23 more nets would follow. Fortuitously, one family owned shares in both net 1 and net 84. After net 83 was launched, that family refrained from launching net 84, and instead launched net 1. Thus, they started a new sequence, excluding one of their own nets (84) and all of the newly registered nets (85–108). That strategy was widely supported by all those who owned limited numbers of shares and by a faction leader who had not participated in the effort to bring in new nets. "As fishing was poor at the time the owners of the new nets did not protest very vigorously, but when the stratagem was repeated in the next cycle, [they] made it clear that they would resist future attempts" (Alexander 1982, p. 225).

That challenge came in 1966, when the net cycle reached net 83. Both net 1 and net 85 were launched at the same time, and fishers engaged in a brawl at sea. The boat carrying net 1 overturned. "Members of all three factions had gathered on the beach, and only the arrival of three jeep-loads of armed police, whom David [Mahattea] had warned in advance, prevented a riot" (Alexander 1982, pp. 225–6). The police stayed on for weeks to ensure that the 24 new nets were added to the sequence. The national government then issued regulations freezing the number of nets at 108. No nets were added to the official list between 1966 and 1971, when Alexander conducted his study. Alexander reports that the actual number of nets in use had dropped to 99 because of the burning of some nets in interfactional conflicts.

I have described this case in some detail because Alexander provides such an excellent record of the key steps in this process of rent dissipation. This was not a problem of ignorance. The fishers involved were aware of the consequences of adding nets. It was not a case of individuals being incapable of devising and enforcing rules well tailored to their local circumstances. The sequencing rules had been practiced successfully for many years. It does illustrate what happens in a *dynamic* local setting when appropriators do not have autonomy to make and enforce new rules.[7]

Before independence in 1948, the British had recognized the position of village headman (*vidāna arrachi*) and an official responsible for all aspects of fishing (*patabändi arrachi*). The village headmen were responsible for a

wide variety of activities in a local village, usually were appointed from among the local landowners, and frequently increased their wealth substantially as a result of holding office. They did have some real representation functions for a village. The duties of that position were abolished in 1965, and a new position was created in the civil service to handle village administrative matters. The occupants of the new offices were in an extremely weak position. They came from other locations and were subject to transfer out of an assignment if local residents with political contacts raised objections. During the year of Alexander's fieldwork in Mawelle, four men were successively appointed to that position, none staying for more than one month. The position of *patabändi arrachi* has continued in existence, but virtually the only task for the incumbent in recent times has been the annual registration of nets.

Sri Lanka has an extensive system of income-redistribution policies that bring central officials into direct contact with citizens on a frequent basis. Even though Mawelle is a relatively isolated village, villagers find themselves having to seek permission from central authorities located in Hambantota for many aspects of daily life:

> They must visit the District Revenue Office to obtain a rice ration book and the Police for a license to tap toddy. Chits to buy a variety of goods ranging from cement to extra food for a daughter's wedding are issued by the Government Agent. The Fisheries Department controls the sale of fishing gear and engine parts, while a number of consumer staples including rice, condiments, textiles and kerosene are sold through state run co-operative stores. In every case the villager is confronted by a shortage of goods, long slow-moving queues, and supercilious clerks. Yet despite the centralised control of goods and services, government agencies have few direct contacts with the village. (Alexander 1982, p. 31)

Political relationships between elected officials and local villagers revolve around patronage positions given to faction leaders in return for electoral support. Relationships inside the village are strongly affected by efforts to obtain private returns from the public treasury.

No arenas were provided by either the British or the Sri Lankan government for local discussion or local decision making at a constitutional-choice or collective-choice level. The villagers' own rotation system was codified in 1933, prior to the dramatic economic changes that would alter the incentives for all participants, and the villagers lost their right to change their own rules to adjust to the rapid change in the value of fish. National officials had promulgated a law that limited entry, but they failed to enforce it. Instead of enforcing entry rules limiting the number of nets, national officials could be convinced with promises of votes (and perhaps even bribes) to intervene and prevent the enforcement of a national rule

considered desirable by most local fishers. In any effort to close entry to a resource, some participants, or potential participants, are strongly motivated to ride free on the restrictions imposed on others. If these participants are able to make an "end-run" around local authorities, rule enforcement can be disrupted even when most appropriators strongly prefer tight enforcement.

Most of the beach-seining operations along the southern shore of Sri Lanka originally used share systems similar to the one described here. Villages that were located in closer proximity to marketing centers succumbed at an earlier date to the problem of rent dissipation. In most of those villages, a single entrepreneur bought up the shares to the local beach-seines and operated the beach-seines as a single firm. The owner hired wage laborers and captured the residual claims to profits. In villages where there were many employers of labor, such systems should have operated efficiently. Where the beach-seine operator held a monopsony position in regard to labor and the supply of labor was abundant, one would expect that the owner would keep wages as low as possible. The distributional consequences of that system frequently were undesirable. Private ownership may have been the only viable institutional arrangement along this coast, not because it was "the only way" but because the external regime was unwilling to allow local rule determination and enforcement. External intervention to prevent rule enforcement against political favorites undermines the viability of common-property arrangements.

IRRIGATION DEVELOPMENT PROJECTS IN SRI LANKA

Millions of dollars have been poured into the development of irrigation works in the dry zone of Sri Lanka. Extensive irrigation works had been developed in that area before the Christian era and had flourished until the twelfth century, when the population dependent on those systems began, for unknown reasons, to migrate to other parts of the island. In the nineteenth century, the British first began to restore the ruins of the bunds (embankments) that had created small and large reservoirs – called tanks in that part of the world – and the long, ribbonlike canal systems that stretched for great distances below the tanks. After independence, the government of Sri Lanka, assisted by foreign donor agencies, continued to invest heavily in irrigation projects.

The quantity of paddy rice produced in Sri Lanka has grown steadily in recent decades, particularly since the 1950s. The introduction of higher-yield varieties of rice has contributed to this growth,[8] but the amount of land under irrigation is the single most important factor affecting the

quantity of rice produced (Madduma Bandara 1984, pp. 298–301).[9] Although the quantity of rice produced has steadily increased, the output is substantially short of the expectations of project planners. In few of these projects has the amount of land actually irrigated approached the projections. Few systematic final evaluations of those projects have been conducted, but the detailed cost–benefit evaluation of the original Gal Oya project showed that discounted costs exceeded discounted benefits by 2.7 million rupees (Harriss 1984, p. 318). The area actually irrigated in another major project – Uda Walawe – was one-third of that planned when the project was funded. Much of the land that the planners presumed would produce two crops per year produced only a single crop after project water was made available.

One source of the disappointing effects on rice production is the discrepancy between project plans and project performance in terms of the amount of water that Sri Lankan farmers actually apply to their paddy lands. To understand this discrepancy, one needs to examine the relation between the quantity of water applied and the yield of paddy rice. Obtaining a high yield is dependent on receiving a substantial and reliable supply of water throughout the growing season. Farmers are strongly motivated to irrigate their fields as often as possible during the growing season. The yield for most varieties of paddy rice, in contrast to grains such as wheat, is highly sensitive to a scarcity of water and relatively insensitive to an overabundance of water (Levin 1980, pp. 52–3). Keeping fields flooded for long periods of time reduces the amount of backbreaking weeding that a farmer must do. A farmer has every reason to take almost any quantity of water that can be obtained through legal or illegal means, and very little reason to conserve water at all.

On the other hand, water is a scarce and costly factor of production. Farmers are rarely required to pay the full costs or even any costs at all for the water they receive. Further, diverting water from areas in the upper reaches of a system, when taken in excess of crop requirements, to be used in downstream areas will not reduce the yields upstream. Such a reallocation will greatly increase the rice yields in the lower reaches. Thus, if farmers are able to follow their own unconstrained preferences, they will apply far more water than is economically justified, in order to reduce their own personal labor input (even in areas where there is an abundance of labor), with the result that the total agricultural yield of the system will be substantially less than the projections made by irrigation engineers based on formulas of "optimal water-usage patterns."

A realistic estimate of actual water use in the major project areas of Sri Lanka is 12–15 feet of water applied to each hectare of paddy fields: 5–6

feet for the major (*maha*) growing season, when precipitation augments irrigation, and 7–9 feet for the minor (*yala*) growing season, when there is little or no precipitation. The most effective use of water to be recorded was in a small pilot project run by the Irrigation Department, with tight controls: a total water use between 8.4 and 10.2 feet. The 1969 project-planning document for the Mahaweli Development Programme – the largest of all the Sri Lankan projects – estimated the amount of land to be irrigated based on a presumption that 8.3 feet of water would be applied to yield two crops of paddy rice. When the project was evaluated again in 1977, planners reestimated the amount of land that could be irrigated assuming that about 7.5 feet of water would be applied over the entire project area to produce two crops of paddy rice (Harriss 1984, p. 319). Thus, the engineering plans were based on the presumption that water would be treated as a scarce good and that strict allocation rules would be enforced. Neither presumption was appropriate (Ascher and Healy 1990; Lundqvist 1986).

Bringing water use close to the figures used in project-planning documents would require a high level of organization by the farmers themselves to allocate water in the channels serving their fields according to strict self-discipline. Central-government efforts to achieve such a level of organization have not changed the fundamental incentives facing participants or their behavior. The dominant pattern of their behavior is to take as much water as their paddy fields will hold whenever they can legally or illegally obtain it and to refrain from active participation in efforts that would require them to accept any limits on their water use. The contemporary structure of incentives facing many farmers reinforces a short-term, "individualistic" strategy and discourages efforts devoted to longer-term investments in the organizational structure needed to achieve collective action. In this system, not only do the upstream irrigators seriously harm the downstream irrigators, but the general lack of reliable rules greatly increases the production and transactions costs for all irrigators.

To illustrate this problem, I shall describe the patterns of incentives and behaviors that evolved in the Kirindi Oya project, a project completed in 1920 under British colonial rule. After describing some of the vicious circles that evolved in that project, I shall then show how similar patterns of incentives have been generated in some other projects. The collective welfare of the impoverished farmers in the dry zone is dependent on their obtaining the additional food and income that would result from the design of an effective and enforceable set of rules for managing irrigation systems to increase their yields. But the farmers in that system are indeed caught in a system that is unlikely to facilitate their achieving an improved system of

rule-ordered relationships without outside help. And officials of the central government are equally trapped – given the current setting – and are also unable to break the vicious circles encompassing them and the farmers they are supposed to be serving.[10]

In 1876, the remnants of a bund located at Ellagala, on the left bank of the Kirindi Oya River, were restored, and a new settlement area was opened up. Thirty years later, a similar scheme was developed to restore a bund on the right bank of the river, using the same diversion works to fill the tank, thus opening up more land for resettlement. The construction phase was completed in 1920. Approximately 2,500 acres are served by this irrigation system. Most of the irrigators served by this system are poor tenants who are dependent on those who own large parcels of land in the area. Many of the major owners of land live elsewhere and are not dependent on local support (Fladby 1983).

The rainfall in the dry zone is 50–75 inches per year, which is a substantial amount when compared with the average for Valencia, Spain, of 10 inches and that for the Los Angeles metropolitan area of 14 inches per year. However, compared with other tropical areas, 50–75 inches is low. More important, it is highly concentrated in the October-to-December period, when dry steambeds are turned into torrential rivers. But everything will be dry a few days later (Gunasekera 1981). There is a minor rainy season in April and May. The irrigation systems restored by the British were relatively primitive structures, with few regulatory sluices or gates. Rainfall was retained behind a bund until the rainy season ended. The amount of water available in the reservoir determined the amount of land that could safely be placed under cultivation for the next growing season. For the smaller tanks, the land area covered by water just about equaled the land area that could be irrigated.

The administrative structure established by the British was designed to run a system that involved the release of water from shallow bunds in short bursts after water had been captured during one of the rainy seasons. Water would then accumulate behind the bund during the next rainy season, later to be released again. Farmers along the entire system had to be prepared to use the water during a brief period of time, or they would miss the opportunity to plant a crop for that season.[11] Under the British, the Irrigation Department named fixed dates for the release of water; the dates were supposed to be invariable each year to ensure time for two crops and for maintenance work on the bund and the channels. The notion of fixed dates was related to "a general view of British irrigation authorities that schemes should operate according to standard programmes so as to be subject to as

little influence from events and personalities as possible" (Harriss 1977, p. 367).

From 1920 to 1958, the Kirindi Oya system was managed by a dual executive structure. In principle, the responsibility for maintenance of the tank and the main canal and for allocation of water to the tank from the river was under the jurisdiction of the Irrigation Department. A subdivisional officer responsible to the director of irrigation engineering was the only person with the power to instruct an irrigation overseer to release water from the tank into the 10-mile-long main channel. Two "watchers" or "water-issue laborers" were then responsible for opening or closing the headgates, composed of simple planks, into the 11 main subchannels and for reporting on the condition of the main channels. All of these officials were paid fixed salaries by the Irrigation Department.

A different line of responsibility started at the level of the farmers' fields. There the lowest official was the *vel vidane*. In an earlier era of British colonial rule, that position was appointive and carried considerable power and prestige.[12] Because many cultivators were tenants, they did not participate in the selection of the *vel vidanes*, who were beholden primarily to the larger landowners for their positions. The *vel vidanes* were responsible for reporting on the progress made in cultivation and could enforce sanctions on cultivators who did not use water according to the rules agreed to by the landowners. They were paid a share of the yield by the cultivators. "In theory the Vel Vidanes were the instrument of swift discipline, empowered to ensure water conservation by the application of a code which laid down automatic punishments for any practices which would waste water, such as poor levelling of fields" (Harriss 1977, p. 369). However, practices varied greatly from one system to another. Some *vel vidanes* were subject "to influence by the big land controllers, so that performance of their duties was often slack and subject to bias" (Harriss 1977, p. 369). Some *vel vidanes* were known for their vigorous efforts to impose rigorous and fair discipline. Although elected locally, the *vel vidanes* were responsible to an assistant government agent (AGA) employed by the Revenue Department. Information about the status of the crops was reported upward from the *vel vidanes* to the AGA.

Water shortages occurred rather frequently. Considerable conflict was engendered between the Revenue Department, which wanted to save crops, and the Irrigation Department, which wanted a regular schedule and a set time to maintain the bund and channels. The AGAs from the Revenue Department regularly requested delays in the timing of water releases in order to prevent destruction of the first crop, which would lead to a lower

tax yield on the land. The effects of such delays were failure of the second crop in many years and a cumulative deterioration in the maintenance of the system. Further, the conflict between the two agencies could be manipulated by the larger landowners, who played on the concern of the AGAs for cultivation, rather than irrigation maintenance, and the somewhat more participatory orientation of the Revenue Department.

John Harriss reports that it was possible to make this system work when a strong AGA considered cultivation a priority. One AGA in the early 1920s was quite successful:

> He was able to resist the pressures of the powerful landowners and to exercise his power ruthlessly with regard to late cultivation, but also to manipulate the Vel Vidane system to make optimum use of available water and offer positive inducements to timely cultivation. For the system did provide for a kind of monitoring organisation throughout the tract. (Harriss 1977, p. 369)[13]

The *vel vidanes* were paid a proportion of the resulting crop, rather than a fixed income. Therefore, when coordination at the tract level was matched by predictability in water releases, there were strong motivations to enforce a discipline on the farmers that would ensure that two crops would be brought through to a successful harvest.

The British system was left substantially intact for the first decade of independence. In 1958 the system was changed by the national government in an effort to make it more democratic. The Revenue Department was removed from any responsibility for cultivation and eventually was replaced by a Department of Agrarian Services, which had no direct supervisory role in irrigation management in large projects, though it was responsible for overseeing and assisting small projects. The *vel vidanes* were replaced by the administrative secretaries (*govimandala sewakas*) of newly created Cultivation Committees. Initially, the "water meetings" held in each tract were attended by all registered cultivators, instead of just the owners of land, and elected a Cultivation Committee for a period of three years. Each Cultivation Committee met separately to set its own cultivation dates for each cultivation season of the year.[14] That arrangement greatly enhanced the flexibility of the system, but reduced the level of coordination across irrigation canals that had been possible when the Revenue Department had responsibility for cultivation matters throughout entire systems. Because most canals were unlined, water releases scheduled frequently throughout a long season, rather than at a few brief periods, would increase the amount of water lost to seepage.

The administrative secretary was responsible for enforcing compliance with the rules for water use, but he had fewer enforcement powers than

had the *vel vidanes*. The administrative secretary was paid from a fixed cash assessment levied per acre of land in each tract, whether or not the land was cultivated. Thus, the incentives of the administrative secretary were different from those of the *vel vidane*: The administrative secretary was no longer formally beholden to a small group of large landowners for his position; he had fewer powers than the *vel vidane* had had, and he was paid a set amount no matter how inefficiently water was distributed and used. On the other hand, he was dependent on satisfying farmers in his unit, to some extent, or he could not be reelected. Also, he was no longer directly accountable to external agencies for his work activity or for providing information about the condition of the crops or the condition of the irrigation works.

Large landowners frequently captured the major positions on some of the Cultivation Committees for Kirindi Oya and obtained special privileges related to water distribution through internal influence or by seeking external political intervention. In the Irrigation Department, one technical assistant became responsible for both the right side and the left side of the Kirindi Oya development. He had one maintenance overseer and two water-issue laborers assigned to him – hardly a sufficient work force to supervise 11 major outlets, many minor ones, and irrigation activities in over 2,500 acres of land (Harriss 1977, p. 371).

Effectively, the system had to operate without the services of coordinators at the tract level. The water-issue laborers were expected only to open and close gates and report damage. In any case, they could not physically limit the amount of water that any group of farmers obtained. Farmers blocked channels easily and forced water to back up into their fields. Disputes among irrigators were sometimes resolved in a violent manner. Farmers who benefited from unofficial channel blockage were not censored by their neighbors who were adversely affected (Harriss 1977, p. 374).

From 1973 to 1977, the members of the Cultivation Committee were appointed by the minister of agriculture, which meant that the local MP effectively controlled the appointment (Fladby 1983; N. T. Uphoff, personal communication). By the mid-1970s, control over water theft was "virtually nonexistent." Although 200 reports of water poaching had been submitted, none had been officially pursued. In the lower portions of the system, "about 80 acres of paddy are irrigated by means of an unofficial channel which blatantly taps the main channel, and disrupts cultivation in the last yaya (tract) irrigated. . . . This has been going on for about fifteen years" (Harriss 1977, p. 372). Those who irrigated at the tail end of this system, as in many systems, had the most unreliable supplies.[15]

Several administrative secretaries indicated when interviewed that they did not file official actions against irrigators for water poaching even though they "regularly file cases in the event of non-payment of the acreage taxes upon which they depend for their remuneration" (Harriss 1977, pp. 372–3). Irrigation rates had not been assessed since 1958. The chief engineer of the system concluded that "there is no law now" (Harriss 1977, p. 373).

The Cultivation Committees were abolished altogether in 1977, and their functions were given to appointed cultivation officers, thus replacing a system that had had at least some communal input, and bringing in an entirely centralized system. A modest change was made in 1980 to create an elected track leader (*yaya nayakaya*), but the position is quite anomalous. Although chosen and paid by the farmers, track leaders are supposed to follow the orders of the cultivation officers. As a result, no one other than the farmers themselves can allocate water or attempt to coordinate actions, at least in some villages (Fladby 1983, pp. 102, 191–5).

None of the participants in the Kirindi Oya project is motivated to do anything but follow dominant strategies. For the individual farmers, the only reasonable strategy to follow in a system in which others steal water with impunity (and use it for weed control) is to flood their own fields as much as possible, using whatever means are necessary to do so.[16] For the large landowners, keeping active political contacts with national leaders is one method of ensuring some protection for illegal practices. Politicians, for their part, interfere with irrigation procedures in order to provide "spoils" for those who support them.[17]

Because of the general personnel structure for Sri Lankan public officials – and especially irrigation engineers – few incentives exist for Irrigation Department staff to devote much time and energy to an attempt to enhance the operation and maintenance of canal systems such as the Kirindi Oya project. Recruitment is based primarily on educational qualifications and passing scores on examinations. Promotion and advancement are based almost entirely on seniority, with little crossing-over between nonprofessional and professional ranks. Irrigation engineers strongly identify with the civil-engineering profession, in which esteem derives largely from designing and constructing public works, rather than operating and maintaining them. Engineers make more money when they are assigned to construction projects than they do when assigned to operation and maintenance duties.

After a detailed analysis of this personnel system, Michael Moore concludes that it impedes efficient water management in several ways: (1) Recruitment patterns "impede effective social interaction between public

servants and cultivators," as well as "internal communication and working relationships which are especially important for water management." (2) Performance in written examinations is not associated with good work performance. (3) "There are in general few incentives for good work performance." (4) The way the bureaucracy is organized "consistently if unwittingly results in the devaluation of performance" (M. Moore 1979, p. 103). These factors lead "to poor work performance in general" and specifically to a lack of "good performance in the operation and maintenance of canal systems" (M. Moore 1979, p. 103). On top of all that, Irrigation Department officials are overworked and underpaid.

Tragically, it appears that similar problems afflict some of the other projects undertaken in Sri Lanka, as well as in other parts of Asia and the Third World.[18] Recently constructed irrigation works in Sri Lanka still are characterized by long distributory canals and few control structures. Measuring the amount of water that is allocated to different canals is extremely difficult, as is simply getting water to the tail ends of irrigation channels (M. Moore 1980, pp. 3–4). Further, the few existing control structures are easily tampered with. After reviewing recent developments, Harriss (1984, p. 322) indicates that "gates are missing, structures damaged, channels tapped by encroachers and others." When asked why they did not prevent some of the more blatant offenses, two young technical assistants replied "that they were afraid to because of the fear of being assaulted" (Harriss 1984, p. 322). Even a brave technical assistant must feel that such actions are futile, given the low probability of actually punishing an offender:

> Prosecutions have to be carried out by the police, who have usually treated water offenses as trivial, and who do not have the same incentives to tackle them as in other cases. Further, delays over court proceedings and the very light fines which have been imposed on those who have been found guilty of irrigation offenses, have made the legal sanctions ineffectual. (Harriss 1984, p. 322)

Irrigators with the appropriate connections to party officials may never be prosecuted at all.

Many settlements are heterogeneous, composed of individuals coming from different regions, castes, and kinship groupings, all of whom are initially poor and dependent on the irrigation projects for housing, initial income supplements, and provision of social services. The way in which settlers have been recruited and selected has also compounded the problem of farmer organization. The major selection criteria have been (1) being landless and (2) having a large family to enhance the labor supply (Harriss 1984, p. 325). At the same time, land allotments distributed to new settlers are supposed (by law) to be passed along intact from one generation to the

next. Although one can understand that attempt to avoid extreme fragmentation of landholdings, the result has been to exacerbate sibling rivalries within families and encourage young men to seek opportunities elsewhere. For some projects, the proportion of young men remaining to work on the family farm has fallen as low as 10% to 15% (Harriss 1984, p. 328). Paddy rice cultivation has always been a labor-intensive business. Given a shortage of family labor, the use of water for weed control to reduce the demands for labor in cultivation seems to make good economic sense for individual families, even though the subsidized water is actually more expensive than would be the marginal costs of an underemployed labor force. It makes little economic sense for a developing country with an underutilized labor supply to subsidize expensive irrigation water and have it allocated in this fashion.

The failure of the Kirindi Oya farmers to develop an effective set of rules for organizing their irrigation system is not unusual for large-scale, donor-funded irrigation systems in Third World settings. The lack of capacity to achieve self-governance appears to stem from internal factors related to the situation of the farmers and external factors related to the regime structure under which they live. Among the internal factors, I would include the following:

1 the very large number of farmers involved,
2 the fact that most farmers are poor settlers who have recently been recruited to the project and have little attachment to their land or to one another,
3 the extreme diversity of ethnic and cultural backgrounds,
4 the opportunity for wealthier farmers to control water through illegal or questionable strategies (potential leaders thus being able to take care of themselves without having to exert leadership to solve larger communal problems), and
5 the lack of physical control structures in the irrigation system itself.

These are difficult problems to overcome. They are exacerbated by the spoils politics of a central regime unwilling to enforce rules impartially, no matter whose rules they are. Those appropriators who want to avoid rule enforcement have considerable opportunity and means to obtain the help of central officials in obstructing such enforcement, thus undermining any effort to supply new local institutions.

The situation facing appropriators in such systems is one of inexorable tragedy. Or is it? Are the farmers on large Sri Lankan irrigation settlements (or similar projects elsewhere) doomed to eternal conflict and lack of cooperation? Unless there are major changes in local institutions, a firm yes

is the only answer. But then the key question is whether or not it is possible to change local institutions and thus the incentives and behaviors of the farmers. A recent experiment in the development of new organizations to enlist the cooperation of farmer-irrigators in one Sri Lankan irrigation system (International Irrigation Management Institute 1986; de Silva 1981) leads me to give a qualified affirmative answer to this second question. The situation is grim, but not hopeless.

A dramatic turnaround story has occurred on the left bank of the Gal Oya irrigation project (Perera 1986; Uphoff 1985a–c). The Gal Oya irrigation system is the largest irrigation-based settlement project in Sri Lanka. The system was completed in 1950. The system has three major divisions: the river division, the right bank, and the left bank. The left-bank division was designed to irrigate about 65,000 acres of land and is composed of "nearly 32 miles of main channels, 150 miles of major distributaries, and about 600 miles of field channels" (Perera 1986, p. 88). By the late 1970s, Norman Uphoff described the Gal Oya left bank (GOLB) as a "hydrological nightmare" (Perera 1986, p. 88). Channels had not been maintained, and their banks were broken and silted. Control structures had been destroyed, and the system was providing water to a much smaller area than originally planned. Further, lack of trust among farmers and between farmers and the officials of the Irrigation Department (ID) was endemic:

> Cooperation among farmers was minimal. Social relations among settlers, who came from different areas of the country, were often strained. . . . Relations between farmers and ID officials were marked by mistrust and recriminations. Farmers had no confidence in the competence or the trustworthiness of the ID's staff. . . . Many field-level officials . . . were notorious for their corruption and thuggery. The main obstacle to efficient water management, from the farmers' view point, was the local-level officials, who had political and bureaucratic power behind them.
>
> On the other hand, the ID officials, especially irrigation engineers, believed that farmers could not use water responsibility and carefully. Therefore, they argued that it was necessary to organize, educate, and discipline the farmers to do what the ID asked them to do. Thus farmers were considered a part of the problem while the latter constitute the solution. (Perera 1986, pp. 89–91)[19]

The entire situation was made even more difficult and tense because "most of the cultivators in the tail areas were Tamil speakers settled from nearby coastal areas while most of the upstream cultivators were resettled Sinhalese" (Uphoff 1986a, p. 202).

The original project design called for regimentation of the farmers and increased law enforcement. That approach was modified to some degree in the final proposal, which called for the organization of farmers throughout GOLB to ensure that farmers would contribute free labor to rehabilitate

and then maintain the channels that served their fields in order to increase efficient use of water. The final project assigned certain funds and responsibility to the Agrarian Research and Training Institute (ARTI) for farmer organization. ARTI was assisted by the Rural Development Committee at Cornell University.

The ARTI/Cornell team, on consideration, rejected the goal stated in the project plan to devise and test a single model of "farmer organization" for all 19,000 farmers served by GOLB within a four-year period. Instead, the ARTI-Cornell team chose to introduce "catalysts" into the situation of mutual distrust and unpredictability – institutional organizers (IOs), as they were called. The IOs could be college graduates, because Sri Lanka has one of the highest educational levels among less-developed countries (LDCs), and many college graduates there were unemployed. As college graduates, they would be able to grasp organizing principles rapidly and would have the status needed to deal effectively with ID officials. To ensure that the IOs were also able to work with the farmers, applicants were recruited who had farm backgrounds – if possible, from large settlements like Gal Oya. IOs also had to be willing to live in the remote project area.[20] The ARTI/Cornell team started development of IOs in a 5,000-acre pilot area near the head of the system, where rehabilitation was to occur first. It has been expanded to 25,000 acres, but does not yet cover the entire system.

The IOs received about six weeks of training in how to approach and motivate farmers and in technical subjects related to agriculture and irrigation. They were divided into small groups of four or five, each group responsible for the area served by one distributory canal. Each team divided its area into smaller units using field canals as the primary basis for division. Each group of IOs met weekly in order to learn from each other's experiences and bolster morale when necessary. IOs also filled in for one another in times of sickness or when one left.

An IO was expected, first, to meet each farmer sharing water from a field canal to discuss the types of agricultural and irrigation problems they faced and to complete a survey of relevant information about the area.[21] After becoming familiar with the farmers and their problems, the IO was expected to meet informally with small groups of farmers sharing the same field channel to plan self-help strategies. Instead of establishing a predefined organization, the IO tried to form a working committee to solve particular problems, such as repairing a broken control gate or desilting a field channel. Further, IOs identified problems beyond those that could be solved by the farmers working together, problems that needed to be articulated to ID officials and others. Once farmers were used to working together and had achieved benefits from group action, the IO would then

help form a local organization and select, through consensus, a farmer-representative. This representative could articulate the interests of the other farmers on his field channel at larger meetings and report back to the others what had happened in larger arenas.

The ARTI/Cornell team tried to get these bottom-up organizations in place before physical rehabilitation started, so as to provide an arena for discussions between the farmers and engineers about the plans for local rehabilitation. In discussions with ID officials, the ARTI/Cornell team used the fact that the farmers were expected to contribute considerable amounts of labor to rehabilitation and maintenance to convince the engineers that high levels of labor contribution were far more likely if the farmers were consulted during the design stages of the rehabilitation. By the time the design phase was initiated, the farmers had already begun to work together and had good ideas about how to rehabilitate their field channels. As a result, irrigation officials began to change their fundamental orientation toward the farmers.

The "field channel organization" (FCO) was the basic organizational building block for the Gal Oya project. FCOs were uniformly small, around 12 to 15 farmers. FCOs were problem-solving units that operated often without regular meeting times, agendas, or written records. A second tier of organization was built on top of the FCO at the level of the distributory channel, the "distributory channel organization" (DCO), involving 200 to 800 acres and around 100 to 300 farmers. Each farmer was thus a member of both an FCO and a DCO. Each DCO developed its own organizational arrangements, which generally involved a general assembly encompassing all farmers and committees made up of the farmer-representatives from the FCOs. Officials were selected by consensus and were nonpartisan.[22]

The third tier of organization, at the branch-canal or area level, was to follow after FCOs and DCOs had been established and linked.[23] There are four major areas in GOLB, and each eventually was represented by an "area council." All of the farmer-representatives within the area served by a branch canal were eligible to attend the general assembly of the area council. The fourth tier of organization – a project-level committee – was initiated by the farmer-representatives and the IOs. The Project Committee provides a forum in which farmers can directly participate in policy discussions. Farmers have seen real changes in the attitudes and behavior of irrigation officials toward them and in the policies adopted by the ID.[24]

Farmer behavior has changed markedly since the evolution of new institutions for collective action. In those areas where FCOs and DCOs have been established, water rotation procedures are quite generally practiced.

In a recent survey, 98% of the field representatives "felt that water rotation leads to equity in water distribution and 79 percent of the farmers felt that they would themselves be assured of adequate water under rotation" (Kasyanathan 1986; Perera 1986, p. 103). Rotations have frequently involved deliberate efforts by those located higher in the system to make water available to tail-enders. That is all the more noteworthy given that head-enders tend to be Sinhalese, and tail-enders tend to be Tamils. On one distributory channel, for example, which straddled the Sinhalese and Tamil areas, little channel maintenance had been undertaken for years. Water deliveries had been extremely unreliable, and farmers talked about previous murders over water disputes (Uphoff 1986a, p. 207). Within a few months of the creation of an FCO, Sinhalese and Tamil farmers began to work on clearing out the channels. Uphoff (1986a, pp. 207–8) described the changes:

> During my visit in January 1983, I observed fifteen Tamil and twelve Sinhalese farmers finishing the cleaning of [the channel]. The thickness of the tree root that had grown through the channel and which the farmers were chopping out by hand was mute evidence that water had not reached the tail in some twenty years. The farmers worked together for three days to get the channel cleaned, just in time for arrival of the season's first water delivery.

The result of that effort was an additional 1,000 acres brought under cultivation, benefitting 300 families who harvested two crops of rice that year (Uphoff 1986a, p. 208). Farmers have regularly participated in group projects organized by their own FCOs to clear the field channels serving their own land and even, at times, to clear distributory channels that were not cleared by officials because of lack of funding. Whereas 80% of the farmers indicated that the record for channel clearing had been poor prior to the establishment of FCOs, only 6% indicated that it was poor in 1986 (Kasyanathan 1986; Perera 1986, p. 104).

The level of conflict among farmers has also declined. "Now with the assured water supply and the availability of a forum, i.e., the FCO, to discuss and settle disputes at the [FCO] level, the frequency and the seriousness of conflicts have been greatly reduced in FCO areas" (Perera 1986, p. 104). During 1985, 77% of the farmers reported that not a single conflict occurred in their field channels over water distribution (Kasyanathan 1986; Perera 1986, p. 104). Because of the nonpartisan nature of the organizations and the bypassing of those who had been the elite, many powerful farmers in the area had originally opposed the organization of farmers at GOLB. By 1983, the opposition from such groups had disappeared, and some politicians had spoken publicly to praise the non-

partisanship of the FCOs and DCOs. Although keeping the organizations nonpartisan appeared to be difficult at the beginning, it was not unusual to find farmers from all parties holding offices in FCOs and DCOs and working well together.

The attitudes of farmers toward the officials of the Irrigation Department changed, as did the attitudes of officials toward the farmers. Officials were perceived as being far more responsive to farmers' needs, and farmers could document specific incidents in which policies had been changed in response to requests made by farmer groups. Over 70% of the GOLB officials believed that official–farmer relationships had improved and that FCOs had facilitated more communication, better understanding, and mutual trust (Kasyanathan 1986; Perera 1986, p. 103). The increased trust crossed ethnic lines. The extent of that mutual respect was demonstrated in 1981 when communal violence broke out in the district, with some roving bands of Sinhalese youths burning Tamil shops in the marketplace: The reaction of the Sinhalese farmer-representatives was to go to the homes of the Tamil Irrigation Department officials in order to protect them from violence (Uphoff 1986a, p. 206).

The major weakness of the Gal Oya organization program was that farmers were expected to undertake construction at the field-channel level without pay. Somewhere between 30% and 60% of the field channels were completed (N. T. Uphoff, personal communication). It probably was an unrealistic hope on the part of the planners to expect farmers to do hard physical work, with little immediate payoff, based simply on a nascent community spirit at the same time that private contractors were making substantial, often lucrative, profits for undertaking the same type of work. The Irrigation Department itself was not able to keep to its planned schedule, complicating still further the task of trying to motivate farmers to do those tasks on time.

No one would argue – least of all the ARTI/Cornell team – that the Gal Oya project operated without minor problems, and sometimes major problems. They faced high turnover (95%) among the IOs, who would leave their temporary jobs when permanent positions opened in the Ministry of Education or elsewhere. Some IOs were fielded with inadequate training. The supervision given to the program was thin on the ground. Some Irrigation Department officials and some farmers were not as responsive as others. But, overall, the modest cost of the program was more than offset by the increased yields resulting from successful introduction of water rotation procedures (Perera 1986, p. 105).

On balance, the Gal Oya project represents a dramatic turnaround in a system in which there once was little hope of gaining farmer cooperation

in the use of water and maintenance of field canals. Beyond gaining the coordinated effort needed to maintain the field channels and equitably distribute water, thus enhancing the efficiency of the system, the project has left organizations in place that can continue to develop new skills and new problem-solving abilities.

Given the perverse incentives that beset all of the participants in Gal Oya prior to the project, it seems unlikely that the farmers or the officials by themselves would have overcome the structure of the situations they faced without external intervention. The type of intervention adopted in the Gal Oya project, however, was not that of a central agency regimenting the farmers by enforcing rules designed by others, although that had been the conception of the intervention in the initial project documents. The ARTI/Cornell team specifically rejected that model of external regimentation. Instead, they chose to facilitate the problem-solving capabilities of local farmers and officials by introducing "human catalysts" who were to work directly with farmers and officials at the field-channel level trying to solve problems. Only after some initial success in getting farmers to undertake collective actions that required some working together did any movement toward more formal organization take place, and even then the field organizations were deliberately kept simple and oriented toward problem-solving. Farmer-representatives were selected through consensus, rather than having "leaders" elected by majority vote. Consensus was the dominant rule used in making decisions at all tiers. Given the spoils systems that had evolved in Sri Lanka, the fact that the day-to-day problem-solving regarding irrigation and agricultural problems could be taken away from politicized channels was an extremely important step.

Mutual trust and reciprocity were nourished on a face-to-face basis prior to attempts to organize farmers into larger groups. At the distributory-channel level, formal organizations were developed by the farmers without following a single, externally authorized model. Eventually, farmers were organized on four mutually reinforcing levels and were given recognition and encouragement. Most important, farmers saw that their own proposals were treated seriously, for the first time, by irrigation officials, and they saw definite results.

The Gal Oya project demonstrates how external agents may help appropriators overcome perverse incentives that lead to suboptimal outcomes, even when traditions of mutual distrust and animosity have been reproduced over several generations. Such problems may be intractable from "inside" the situation unless the major participants holding diverse positions can simultaneously be shown the necessity for major changes in the incentive structure facing them all.[25] The amount of external intervention

need not be large nor expensive. Nor is it necessary to maintain large numbers of catalysts in the field for a long time. For a program such as this to be successful, it is necessary that both farmers and irrigation officials come to view the resulting farmer organizations as legitimate and permanent tools for coping with the long-term problems involved in the governance and management of any complex irrigation system.[26]

THE FRAGILITY OF NOVA SCOTIAN INSHORE FISHERIES

The cases discussed earlier have illustrated some of the problems that make it difficult for CPR appropriators to develop effective rules for limiting entry and use patterns. Now I wish to turn to a different type of problem – that of fragile CPR institutions. Some fragile institutions devised by CPR appropriators are still in use and effective. These institutions exist, however, in a broader setting that renders doubtful their continued use and effectiveness.

The eastern coast of Canada is dotted with small fishing villages where fishing has been the major economic activity for generations. The fishers in many of these villages, particularly those located in Nova Scotia and Newfoundland, have developed their own rules governing the use of nearby fisheries. These local rule systems control who can enter the fishery and how local fishing grounds are divided among fishers using different technologies. In some cases the fishers have established lottery systems to allocate the best locations for setting traps or nets.[27] The local rules that have evolved for one Nova Scotian village are described in considerable detail by Anthony Davis (1984) for a village he calls "Port Lameron Harbour."

Almost all of the 99 fishers currently using Port Lameron Harbour are descendants of fishers who settled in the area during the last decades of the eighteenth century. They all fish from relatively small boats, even though 10 of the 52 boats fish in the offshore waters. Most inshore boats cost less than $30,000, whereas offshore boats tend to cost around $50,000. The average crew size on the inshore boats is 1.8, and on the offshore boats 2.5 (A. Davis 1984, p. 135).

The fishers engaged in the offshore fishery are on the water throughout the entire year, repairing their boats from time to time as needed. The inshore fishery is conducted from the end of March through December, when the boats are hauled up on the shore for repair and refitting. Both types of crews use a diversity of fishing technologies and seek out various species (cod, halibut, herring, mackerel, lobster), depending on the time of year. There are differences in value, size, and technologies between the

inshore and offshore fishing boats, but they are not as substantial as the difference between the various types of fishers in Bodrum and the Bay of Izmir described earlier.

Most of the fishing villages along the southwestern coast of Nova Scotia have broadly defined fishing territories.[28] The Port Lameron Harbour inshore fishery zone extends outward for about 25 kilometers and along the coast for about 20 kilometers. The offshore boats use the outer portion of that fishing ground and also go considerably farther to sea. The territory used primarily by Port Lameron fishers is divided into several subzones, each devoted to a particular type of technology. Herring and mackeral gill nets are set in a rectangular area beyond the harbor but close to shore. If they were set farther inshore, they would restrict travel in and out of the harbor, and if set farther to sea they could be destroyed by the strong currents. Similar areas are set aside for lobstering, when it is in season, and for various potentially conflicting technologies used to obtain cod and halibut.

Basically, the Port Lameron fishers have divided their territory on pragmatic grounds: which microenvironments are best suited for which technologies at particular seasons of the year. These use patterns "reflect practical and informal resource management strategies developed by a community of fishermen through years of experience" (A. Davis 1984, p. 145). Not all technologies are mutually compatible in this environment. Four of the captains of offshore boats, for example, purchased offshore groundfish gill nets in 1975 when substantial federal subsidies were offered for such purposes. Their use, however, substantially interfered with the operations of the other inshore and offshore boats. As a result of the intraharbor opposition to the use of those gill nets, all four captains had disposed of that gear by 1980.[29] The division of the territory into zones to be used by fishers using particular technologies not only reduces the externalities that the use of one technology may impose on others but also constitutes a low-cost system for apportioning a reasonable yield to all participants. The cost of monitoring an apportioning scheme based on an easily observable factor – what technology a boat is using – is much lower than the cost for one based on the quantity of fish harvested.

The claim of Port Lameron fishers to the use of their fishing grounds is based on tenure: For generations, they and their families have fished and jointly managed this resource. As expressed by a local fisher,

> I've fished here all my life. So did my father and his father. Men in my family have been fishin' here for a long time. If anyone's got a right to fish here it's me and I'm no different than most of the fellas fish'n here. (A. Davis 1984, p. 145)

They see themselves as having exclusive rights to their lobster territory, which can yield up to 40% of a fisher's yearly income. In addition, they exercise the right of first access (and the right to refuse access in years of scarcity) to the remaining zone. Although some fishing by neighboring fishers is tolerated in good years, the property lines are drawn tight when the fish are scarce. The years of scarcity are, of course, exactly the years when conflict over territory can erupt. Policing their boundaries is something that all fishers do. The burden of enforcement must be borne by the local fishers, as they cannot call on external authorities to enforce their local rules of access. Davis illustrates how this enforcement is done:

> For example, a Port Lameron Harbour fisherman, after setting his longline gear, watched a fisherman from a neighboring harbour set his gear close to and, on occasion, across his line. Subsequently, the Port Lameron Harbour fisherman contacted the "transgressor" on the citizen band radio to complain about this behaviour. Other Port Lameron Harbour fishermen who were "listenin' in" on the exchange demonstrated support for their compatriot by adding approving remarks once the original conversation had ended. The weight of this support, coupled with the implied threat of action, i.e., "cutten' off" the offender's gear, compelled the erring fisherman to offer his apologies. (A. Davis 1984, p. 147)

This rule system is fragile because it is not recognized by federal authorities in Canada, particularly the Department of Fisheries and Oceans (DFO). Fishery policies in Canada have undergone substantial changes over the years. At an earlier date, the provinces played a much more important role in the regulation of inshore fisheries. That was particularly the case in Newfoundland, which was not included as part of the confederation until 1949. The regulatory stance taken by Newfoundland authorities was to provide arenas in which conflict between fishers using different territories and different technologies could be resolved. The Newfoundland fisheries regulations basically codified into law the fishing rules devised in local settings (K. Martin 1979).

The federal stance toward local rules has been exactly the opposite. Current Canadian policy gives "little credence to the ability of local customary regulations to adequately police the fishery" (Matthews 1988, p. 6). Federal officials presume that the entire eastern coast is an open-access fishery.[30] They have adopted the dominant policy orientation described in Chapter 1, namely, that there are only two options available: private property rights and government regulation. Ruling out private property leads to an official policy of federal-government regulation:

> The federal government . . . carries the jurisdictional responsibility for conserving fisheries resources . . . and for allocating the distribution of these resources among

competing users. Since the establishment of private-property rights in fishery resources is impracticable in the great majority of cases, the state's responsibility for resource conservation and allocation cannot be delegated.

(Government of Canada 1976, p. 20)

The deep-sea fishery off the eastern coast has long been an open-access fishery, as most offshore fisheries are. The competition from foreign fleets for these productive fishing grounds led to severe stock depletion in many instances prior to 1976, when Canada claimed jurisdiction over a 200-mile extension beyond its coastline under the "Law of the Sea Convention." That extension of Canadian authority enabled Canadian officials to begin to cope with the open-access nature of the far-offshore fisheries. That extension of authority also led Canadian fishery planners to believe that they were then "in a position to 'rationalize' all aspects of the fishing industry including the inshore and processing sectors" (Matthews 1988, p. 8).

Many of the government's initial steps have been related to efforts to license fishing vessels, as well as the fishing activities of different sorts. Given that many full-time and part-time fishers fear that licensing is only the beginning of an effort to reduce the number of fishers in the industry in general, many individuals who were not currently active in fishing obtained commercial fishing licenses so as to ensure that they would already have licenses if limits were later imposed. Further, given the variety of fishing technologies used by Port Lameron fishers, the immediate response of fishers in that community was to obtain licenses for technologies they were not using in case they might need them in the future. Similar practices were undertaken in other regions. Parzival Copes (1983, pp. 16–17) reported that the number of fishers registered in Newfoundland rose from 15,351 in 1974 to 35,080 in 1980, and he estimated that there were only 21,297 persons actually fishing.

The importance of such "defensive" licensing practices was brought home to Port Lameron fishers who had not obtained licenses to set gill nets to obtain herring for their bait. When federal officials then froze the number of licenses available, without prior notice, and threatened sanctions against those found using gill nets illegally, conflict exploded in the community:

Several fishermen reacted angrily when told that they could not obtain a license unless they currently held one and that fisheries officers would confiscate the unlicensed set nets. One man exclaimed that: "If they touch my nets they'll get a surprise!" (A. Davis 1984, p. 157)

Protest meetings were held along the entire coast, leading federal officials

to back off long enough to allow fishers to obtain herring licenses whether or not they intended to sell herring. The entire experience reinforced local feelings that federal officials would tend to act arbitrarily without consultation and devise regulations that were not well tailored to the local circumstance:

What do they know about what we do? Fisheries Officers are only around here now and then. How do they know what's best for us? We've fished here for a long time and we know what's best for our ground. We know what it can take.

(A. Davis 1984, p. 156)

Instead of finding means for strengthening locally evolved rules systems to ensure that access and use patterns would continue to be controlled in those territories where effective rule systems had already been devised to match local environmental and technological systems, Canadian policy has been to develop one standard set of regulations for the entire coast. If future Canadian policies produce still further counterproductive reactions on the part of the fishers, they may fail to gain control of the open-access deep-sea fishery and lose control of some inshore fisheries previously subject to entry control.

It is difficult to tell exactly what the future holds for fisheries like that offshore of Port Lameron Harbour. If national policies were to change, and officials were to try to develop a set of nested rules that would help enforce the local regulations that have been developed over the years, while focusing most of the new regulatory effort on the far-offshore fisheries that are indeed open-access, then this fragile rule system could survive, adapt, and enable fishers to make effective use of this local resource indefinitely into the future.[31] However, if Canadian authorities continue to try to develop a single policy for all fisheries along the entire eastern coast, then eventual deterioration of the locally evolved system seems probable. Further, it is doubtful that any national agency can ever have the extensive time-and-place information needed to tailor a set of rules to the particulars of local situations.

Federal officials in Canada are not the only officials who have presumed an absence of local institutions for regulating CPRs and have taken actions that have either threatened or destroyed existing institutions. Cordell and McKean (1986) describe a form of sea tenure developed by poor, black raft fishers living along the coast of Bahia in Brazil – tenure that is not recognized by national, regional, or local governments in Brazil. Further, the official policy of the Brazilian government is open access, rather than the limited-access system of the raft fishers. Brazilian national fishing codes

define all Brazilian territorial waters as public waters *open to any Brazilian boat* registered in a Brazilian port.

Several scholars have documented what occurred when the government of Nepal passed the "Private Forests Nationalization Act" (Arnold and Campbell 1986; Bromley and Chapagain 1984; Chapagain 1984; Messerschmidt 1986). Whereas the law was officially proclaimed to "protect, manage, and conserve the forest for the benefit of the entire country," it actually disrupted previously established communal control over local forests. Messerschmidt (1986, p. 458) reports what happened immediately after the law came into effect:

> Nepalese villagers began free riding – systematically overexploiting their forest resources on a large scale. The usual explanations for this free riding are that the villagers felt they had lost control of their forests, and they were distrustful of government control and national resources policy.

In 1978, the government of Nepal reversed its policy and began to encourage the transfer of forest land back to village control, with quite encouraging results in regard to forestation efforts (Arnold and Campbell 1986). Similar stories of disruption of fragile CPR situations, when central-government officials have presumed an absence of local institutions, can be told for many other parts of the world.

LESSONS TO BE LEARNED FROM COMPARING THE CASES IN THIS STUDY

The purpose of presenting these instances of success, failure, and fragility is to determine what these cases have in common. Now that the cases have been described, I shall use them for two types of analysis. First, I shall compare the extant institutions using the design principles described in Chapter 3: Which of the design principles derived from the robust institutions described in Chapter 3 characterize the other cases? If the cases of institutional failure and fragility are characterized by design principles similar to those of the robust institutions, then perhaps those principles should be rejected as not helping to distinguish among robust, fragile, and failed institutions. Second, I shall analyze the situational and regime characteristics that appear to affect the capacities of individuals to change their institutions (as described in Chapter 4 and, for cases dating from earlier times, in Chapter 3), as well as factors that appear to limit the capacities of individuals to change their own institutions (or prevent external changes being imposed on them), as described in this chapter. The first analysis is

the topic of this concluding section. The second analysis is addressed in Chapter 6.

As a first step toward assessing the validity of the proposed design principles, I have arrayed all of the cases discussed in this study in Table 5.2. For each case, I have indicated which of the design principles clearly apply, which apply in a weak form, and which clearly do not apply. The long-enduring cases presented in Chapter 3 obviously are characterized by these principles, because the principles were devised to summarize factors common to these cases. The institutions developed in Raymond Basin, West Basin, and Central Basin to prevent their destruction are also characterized by these design principles. Those institutions have already shown themselves capable of surviving for 30 or 40 years. I am willing to presume they are robust.

These principles also clearly differentiate between the success and failure cases. Turning to the failure cases, none of the principles characterize the two Turkish fisheries (Bay of Izmir and Bodrum), where severe rent-dissipation problems continue unabated. Only one of the principles characterizes the Kirindi Oya irrigation project in Sri Lanka (clear boundaries); two characterized the Mawelle fishery after 1938, when rent dissipation became a severe problem (congruent rules and monitoring); two characterized Raymond, West, and Central basins prior to the institutional changes initiated there (conflict-resolution mechanisms and recognized rights to organize); three characterized the Mojave case (collective-choice arenas, conflict-resolution mechanisms, and recognized rights to organize). Thus, no more than three of the design principles characterized any of the cases in which CPR appropriators were clearly unable to solve the problems they faced.

In this chapter, I characterize the CPR institutions in Port Lameron, Canada, as fragile. I also consider the institutions devised in Alanya, Turkey – though ingenious – to be fragile, as well as those devised for the Gal Oya project in Sri Lanka. Let me explain why. Although the rules devised in Alanya provide an elegant way to solve an assignment problem, they do not address the problem of limiting access to the local fishery. At the current time, the number of fishers desiring to fish in Alanya does not threaten the viability of the fishery. But if more individuals were to want access to the fishery, the problem of rent dissipation that characterized Mawelle could well arise in Alanya. In the past, collective choices were made partly through the facilities of a local co-op and partly through discussions in the local coffeehouse. Without a regular arena for collective choice, it would be difficult for the Alanya fishers to adjust their rules in the future if conditions were to change.

Table 5.2. *Design principles and institutional performances*

Site	Clear boundaries & memberships	Congruent rules	Collective-choice arenas	Monitoring	Graduated sanctions	Conflict-resolution mechanisms	Recognized rights to organize	Nested units	Institutional performance
Törbel, Switzerland	yes	yes	yes	yes	yes	yes	yes	NR[a]	robust
Japanese mountain villages	yes	yes	yes	yes	yes	yes	yes	NR	robust
Valencia, Murcia, & Orihuela, Spain	yes	yes	yes	yes	yes	yes	yes	yes	robust
Raymond, West, & Central basins (current)	yes	yes	yes	yes	yes	yes	yes	yes	robust
Alicante, Spain	yes	yes	yes	yes	yes	yes	yes[b]	yes	robust
Bacarra-Vintar, Philippines	yes	yes	yes	yes	yes	yes	yes	yes	robust
Alanya, Turkey	no	yes	weak	yes	yes	weak	weak	NR	fragile
Gal Oya, Sri Lanka	yes	yes	yes	yes	[c]	weak	weak	yes	fragile
Port Lameron, Canada	yes	yes	weak	yes	yes	yes	no	no	fragile
Bay of Izmir & Bodrum, Turkey	no	no	no	no	no	no	weak	no	failure
Mawelle, Sri Lanka	no	yes	no	yes	yes	no	no	no	failure
Kirindi Oya, Sri Lanka	yes	no	no	no	no	no	no	no	failure
Raymond, West, & Central basins (earlier)	no	no	no	no	no	yes	yes	no	failure
Mojave groundwater basins	no	no	yes	no	no	yes	yes	no	failure

[a]NR = not relevant.
[b]With two major exceptions, from 1739 to 1840 and 1930 to 1950.
[c]Missing information.

In regard to Gal Oya, boundaries and membership have been clearly designated, congruent rules have been devised and monitored, and collective-choice arenas have been set up. Until the rights of farmers are clearly recognized and guaranteed and conflict-resolution mechanisms are in place, however, I am unwilling to assume that these are robust institutions. Given the long history of central control, it would be difficult for farmers in Gal Oya to continue their organized efforts if a major change in the Irrigation Department were to place in office engineers who presumed that local farmers had little to offer. The fragile cases stand as intermediate cases in terms of the design principles. Enough of the principles are in use to enable appropriators to solve some of their immediate CPR problems, but one would be hesitant to predict institutional endurance unless further institutional development occurs and the arrangements come closer to meeting the full set of design principles.

The cases discussed in this volume compose a limited set. Further empirical and theoretical work is needed before one can have a high degree of confidence that this set of design principles is the best way to distinguish among robust, fragile, and failed institutions. Several colleagues and I currently are collecting information on a large set of empirical cases to determine if the pattern of relationships shown on Table 5.2 is replicated. An initial explanation of why these design principles would be associated with robust institutions was presented in Chapter 3. Sufficient support for those initial theoretical speculations is presented in Table 5.2 that further theoretical and empirical analyses appear warranted.