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Ecologically Effective Social Organization as a Requirement for Sustaining Watershed Ecosystems

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Symbiotic relationships mean creative partnerships. The earth is to be seen neither as an ecosystem to be preserved unchanged nor as a quarry to be exploited for selfish and short-range economic reasons, but as a garden to be cultivated for the development of its own potentialities of the human adventure.

René Dubos (1976)

Abstract

The social sciences can make significant contributions to solving watershed management problems. Sustainable watershed management requires knowledge about ecologically effective forms of social organization. Including humans as a component of the ecosystem permits scientists and policy makers to consider how resource management activities affect biophysical processes regulating ecosystems. A major reason for the failure of human societies to develop sustainable resource management activities has been the limitations on their ability to acquire and process ecological information. Difficulty in maintaining adequate information on the state of ecological systems originates in the inability of people to develop an effective cognitive map of their environment. Institutional structure has a major influence on cognitive learning of environments, and institutional arrangements determine the scale of human social organization and the incentives for people to learn and adopt ecologically sustainable practices. Institutionalization of sustainable resource and ecosystem management practices will require better information about the appropriate scale and form of social organization. Small, flexible institutional units may be best suited for the adaptive learning necessary to achieve sustainable resource management.

Key words. Sustainability, resource management, institutions, environmental learning, watershed management, social adaptability.

Introduction

Conceptual separation of humans and natural ecosystems is reflected in the thinking of most natural resource management professions, including forestry, wildlife management, fisheries, range management, and watershed management (Burch 1971). Such thinking can deny the reality of the human element in local, regional, and global ecosystems (Bonnicksen and Lee 1982, Klausner 1971, Vayda 1977). As complex organisms with highly developed cultural abilities to modify their environment, humans directly or indirectly affect almost all terrestrial and aquatic ecosystems (Bennett 1976). Consequently, information for managing watershed ecosystems is incomplete without consideration of human institutions and activities.

Sociologists have studied the relationships between human societies and the land base or ecosystems on which they depend for over 60 years (Field and Burch 1990). These studies are distinguished by (1) a holistic perspective that sees people and their environments as interacting systems, (2) flexible approaches that permit either the environment or human society to be treated as the independent variable in analyzing of society-environment relations, and (3) accumulation of a substantial body of knowledge about how the future welfare of a society is influenced by its uses (or misuses) of land and water (Firey 1990). A more comprehensive approach to stimulating rapid accumulation of knowledge has been promoted in recent years, including the development of a Natural Resources Research Group in the Rural Sociological Society, a biennial Symposium on Society and Resources Management, a new journal (*Society and Natural Resources*), and a series of edited volumes (Miller et al. 1987, Lee et al. 1990).

As a result, social science expertise has been successfully applied to several contemporary resource management problems, including social impact assessment (Burch and DeLuca 1984, Finsterbusch and Wolf 1980, Wenner 1987), public involvement (Carroll 1988, Wondolluck 1988), stability of resource-dependent communities (Lee et al. 1990, Machlis and Force 1988), residential settlement in nonurban environments (Blahna 1990, Fortmann and Starrs 1990, Bradley 1984), and recreational carrying capacity (Burch 1984, Moore and Brickler 1987, Stankey et al. 1985). Other problems also require the application of substantial social science expertise. This article extends accumulated sociological and anthropological knowledge to the problem of sustainable natural resource management. The concept of sustainability originated with attempts to manage biologically renewable resources such as fisheries and forests. According to this purely physical concept, "sustainability means using no more than the annual increase in the resource without reducing the physical stock ... using the interest earned from a savings account but leaving the principal invested to continue to generate interest in the future" (Dixon and Fallon 1989:74). A biologically determined harvest rate called the *maximum sustained yield* was assumed to continue indefinitely with the adoption of appropriate harvest and regeneration practices.

But physical sustainability has proved to be far too simple a concept to guide policy development and implementation. Left unanswered are questions of social and individual welfare involving choices about who will benefit and when (Norgaard 1988). The distribution of benefits within and between generations calls for difficult policy choices, especially when population growth will reduce future per capita resource consumption and there is uncertainty whether technological advances can increase efficiency in resource supply (Dixon and Fallon 1989).

The problems of intergenerational equity are central to the Brundtland Commission report, *Our Common Future*, since it defines sustainable development as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development 1987:8). Sustainable development implies human activities that address the "limitations imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities." The Commission report clearly states that substantial legal, institutional, and economic changes are necessary to achieve sustainability. Humans, including their industrial activities, are considered to be integral parts of the biosphere.

Hence sustainability is fundamentally a problem of human social organization and technology, not simply management of the physical environment and its biological processes. Technology and social organization can limit what is done to adapt to the constraints imposed by ecological processes. But technology, together with the social and industrial activities it supports, also provides some of our greatest opportunities for harmonizing human activities with larger ecological processes.

This article examines ecologically effective social organization as a requirement for ensuring the sustainability of watershed ecosystems. It begins with a review of some reasons people fail to develop sustainable ecological activities because of structural limitations in their ability to acquire and process information. This is followed by a detailed discussion of how humans have institutionalized ecological processes—how institutional arrangements can help people overcome problems in processing information. Institutional arrangements that may be more appropriate for ensuring sustainability are explored. Examples are interwoven with this discussion to illustrate unsuccessful and successful approaches to institutionalizing the sustainability of watershed ecosystems.

Sources of Failure to Institutionalize Sustainability

History is replete with the failures of societies to perpetuate ecological processes supporting human populations (Thomas 1956). Declines of classical civilizations in the Middle East and North Africa and contemporary defo-

restation in the tropics are only two examples (Perlin 1989). Although changes in climate may have played a role in deforestation and in failures of agriculture, social and economic factors have often been more important influences because of their impact on land use decisions. We see this in the short-term political and economic expediency of contemporary land use decisions. There is no reason to believe that social and economic factors were not equally important historically. What are some of these factors and how did they affect sustainability?

Two primary requirements for sustainability are the use of ecological information in decision making and, given such information, successful control over human activities. We will begin with a discussion of how inadequate information flow can limit sustainability and then will turn to the institutional regulation of human activities that affect ecological processes.

Information Flow Pathologies

McGovern et al. (1988) discuss "information flow pathologies" that have limited the successful adaptation of people to ecological conditions. They use the term *information flow* to express the assumption that humans react "not to the real world in real time, but to a cognized environment filtered through expectations and a world view which may or may not value close tracking of local environmental indicators" (p. 245). They note that even the most technologically advanced modern societies have difficulty maintaining adequate information on the state of ecological systems, including problems of maintaining current, accurate, and properly scaled (localized) information. Chandler (1990) pioneered new opportunities for studying how modern land managers can learn about the ecological systems they manipulate when he extended McGovern's work to the study of traditionally derived agrosilvicultural systems in China.

Seven factors may result in maladaptive information flow. McGovern et al. (1988:245) listed the first six, Lee (1991) suggested the seventh.

1. *False Analogy*. The managers' cognitive model of ecosystem characteristics (potential productivity, resilience, and stress signals) is derived from another ecosystem, whose surface similarities mask critical threshold differences from the managers' ecosystem.

2. *Insufficient Detail*. The managers' cognitive model is overgeneralized, and does not adequately allow for the range of spatial variability in an ecosystem whose patchiness is better measured in resilience than in initial abundance.

3. *Short Observational Series*. The managers lack a sufficiently long memory of events to track or predict variability in key environmental factors over a multigenerational period, and are subject to chronic inability to separate short-term and long-term processes.

4. *Managerial Detachment*. The managers are socially and spatially distant from agricultural producers who carry out managerial decisions at the lowest level and are normally in closest contact with local-scale environmental feedbacks.

5. *Reactions Out of Phase*. Partly as a result of the last two factors, the managers' attempts to avert unfavorable impacts are too little and too late, or they apply the wrong remedy.

6. *S.E.P. (Someone Else's Problem)*. Managers at many levels may perceive a potential environmental problem but feel no obligation to take action, since their own particular short-term interests are not immediately threatened.

7. *Ideological Beliefs*. Managers conform to ideological beliefs shared by generalized publics and overlook particular ecological details and management practices. Unquestioned moral commitments to the principles of capitalism, socialism, environmentalism, and other ideologies can divert the managers' attention from the problems of attending to particular ecological conditions (Lee 1991, Schiff 1966).

The first three causes for maladaptive information flows are most likely to be encountered when people first colonize a region, but diminish as they "learn" the new ecosystem (McGovern et al. 1988). The fourth, fifth, and sixth factors appear most often in highly differentiated societies with complex public or private institutional arrangements for managing ecosystems. The seventh can be found in societies at all stages of development, but is frequently revealed in the behavior of large public land management bureaucracies in contemporary societies (Schiff 1966).

The fourth, fifth, and sixth pathologies can be reduced by altering the institutional arrangements to make decision makers more responsive to localized ecological conditions. The effects of the seventh can be diminished by increasing the authority and responsibility (including real accountability) of localized ecosystem managers and improving the integration of scientific learning with decision making.

Institutionalization of Behavior in Relation to Ecological Processes

The sociological concept of *institutionalization* can make a significant contribution to understanding how the processing of ecological information is affected by human organization. Institutionalization involves the development of persistent patterns of human behavior expressed as formalized rules, laws, or customs or as informal rituals and patterns of social interaction or interaction with the nonhuman environment (Berger and Luckmann 1966). Just as repeated patterns of human social interaction are institutionalized, human manipulation of ecological processes reflects regularized patterns of human behavior that are similarly institutionalized. Two examples will suffice.

Shifting cultivation has persisted relatively unchanged for thousands of years. Even-aged management of forests involving clearcut harvesting became the dominant form of industrial wood production on both public and private lands in North America during the 1950s. When shifting cultivation

is practiced in its more traditional forms, it involves making relatively small clearings in a forest so that food crops can be grown until soil fertility is exhausted, at which point the plot is largely abandoned and the forest recovered through natural succession. Over many generations land managers learned to adapt cropping cycles and practices to particular ecological conditions. Although the general pattern of rotation cropping was institutionalized, particular practices were not so highly prescribed that trial and error could not be used to adapt this management regime to localized conditions.

Industrial wood production under an even-aged management regime involves clearing large areas of forest and controlling species composition so that biomass accumulation occurs in species of trees with the highest commercial value. Like intensive agriculture, it short-circuits natural processes of succession, simplifies ecological structure, and channels the flow of energy and cycling of materials along pathways that are most productive of commercially valuable products (Kimmins 1987). Managers learned very quickly how to minimize production costs in order to maintain or increase profit margins.

Institutionalization of industrial wood production constrained learning to economic considerations and may have prevented an adequate flow of information on how best to adapt to ecological conditions (longer-term ecological adaptability was "someone else's problem").

Wherever ecological processes are appropriated and patterned by human society, we can refer to them as *institutionalized ecological processes*. This term refers to the ways in which humans regulate structural components of ecosystems or alter the flow of energy or cycling of materials.

The concept of institutionalization also helps us understand how regulated ecological processes are stabilized and persist relatively unchanged for long periods. Walter Firey, a distinguished sociologist who studied natural resources, dedicated his career to investigating the conditions under which the human use of ecological systems could be sustained. Firey (1963:150) referred to basic issues that underlie sustainability when he stated "there are many kinds of activities which, by their very nature, require some kind of orientation on the part of human agents to a remote future." He struggled with the same problems we find so troubling when he said:

> Thus the cultivation of certain perennial tree crops, such as the olive, cocoa, and pecan, presupposes many years of care before the cultivator will reap any marketable crop at all. Sustained yield management of forests in several European countries has involved reproduction cycles of more than a century. Amortization of capital investments in some mining and plantation enterprises often transcends the span of a single generation. Maintenance of soil fertility in peasant cultures, such as those of Europe and China, has imposed costs upon generations who have never realized any compensation for their trouble.

Firey sought to explain how societies motivated people to work for objectives that would not be realized during their lifetimes, and posed two questions (pp. 150–151): "is this sacrificial effort by one generation for the welfare of another generation the function of explicit future-referring values? Or is it rather an epiphenomenal manifestation of certain structural properties of the social orders in question?"

Firey understood American culture and its unquestionable commitment to the ideal of natural resources conservation—a value that by the 1930s had taken on the force of a "moral imperative." Yet he observed great disparity between the idealistic commitment to conservation and the actual behavior of people who managed natural resources. Studies of soil and water management showed that the future-referring values were insufficient to motivate farmers to practice conservation. Farmers did not necessarily implement the idealistic values of the culture they shared.

Firey (1960, 1963) concluded that conservation behavior requires at least two conditions, in addition to being biologically possible: (1) individuals must internalize values, and (2) these values must be articulated socially in ways that motivate conformity; that is, they must be both expedient (gainful for the individual or group) and psychologically satisfying (maintain self-esteem and group identification). In short, they must be institutionalized.

Firey noted that values that do not become institutionalized in the form of ongoing social relationships can have only an ideological status. He observed that conservation values in contemporary American culture are largely ideological. "Sustainability" seems to have acquired a similar ideological status as a political slogan popularized during the 1980s (Dixon and Fallon 1989).

There has been very little progress in understanding that values must be institutionalized before they can affect behavior. Yet this principle was well understood before Firey's time, and was stated by Erich Zimmerman (1951:376), the noted resource economist: "all perennial culture, but particularly the planting of trees, rests on the stability of social institutions. No one would be foolish enough to spend a decade or more . . . to build up an olive grove which can bear fruit for a century unless he feels reasonably sure of a reward for himself and his descendants."

The record of international development efforts in forestry has convincingly documented the importance of stable institutional conditions for attaining sustainability. People in developing countries have not been willing to plant and tend long-maturing crops such as trees when the chances of realizing gains are diminished by unstable land tenure arrangements, inadequate control over fire and grazing, and an inability to enforce property rights in land or trees (Fortmann 1988). They have also abandoned centuries-old silvicultural systems when the ground rules of tenure, rights, and control were disrupted by unpredictable change (Chandler 1990).

In summary, sustainability is only possible if humans behave in ways that do not eliminate essential ecological options for future generations. Existing behavior may be institutionalized in nonsustainable patterns, such as road building on steep, unstable slopes. Or it may be rechanneled in ways that will provide incentives for people to learn how to adapt their behavior to

ecological processes. But, most important, successful institutionalization of behavior results in people following routines and believing that these routines are morally right. There is far less need for coercion and formal social control when people voluntarily, or habitually, adhere to patterns of behavior (Berger and Neuhaus 1977).

Alternative Institutional Arrangements for Managing Watershed Ecosystems

Divisibility of Institutionalized Ecological Processes

Many of the problems in watershed management are fundamentally sociological in nature, since they involve issues of scale in the divisibility of institutionalized ecological processes. The contribution Freeman and Lowdermilk (1981) made to understanding the divisibility of irrigation technology provides a useful framework for understanding how ecological processes are institutionalized at different scales. An institutional pattern of behavior is divisible if it can be organized in both small and large spatial units. It is perfectly divisible if regulation of the ecological function is insensitive to scale. For example, the growth of individual trees or the building of residences is highly divisible because landowners with small plots as well as large tracts can plant and care for trees or build houses. By contrast, an indivisible ecological function is one in which there exists some spatial threshold below which it is not possible to regulate the ecological process. Regulation of atmospheric carbon is highly indivisible because it involves global cycling driven by atmospheric processes.

Divisibility is not always easily determined. Conventional patterns of social, economic, and political behavior affect the degree of divisibility in the regulation of ecological processes. Divisibility is relatively high in societies that have retained an autonomous ecological role for families and small communities (Padoch 1986), as contrasted with centralized command economies where state regulation has replaced localized decision-making authority (Chandler 1990). Divisibility may be low when centralization is essential for mobilizing the capital or social organizational requirements for resource development and utilization (Freeman and Lowdermilk 1981). A major irrigation project involving dams, aqueducts, and terracing of agricultural plots is a relatively indivisible agricultural system (Smith 1978). The functional necessity for larger scale in irrigation projects can be contrasted with the conventional structure of large-scale corporate silviculture in many industrialized and industrializing countries. Since corporations are conventional instruments for mobilizing capital, it is often assumed that large-scale corporate ownership is essential for capital-intensive silviculture. However, institutions for mobilizing capital are generally insensitive to scale—allowing small owners to be equally successful in making capital-intensive investments when political and economic conditions are suitable for small-scale investments.

The spatial organization of ecological processes can provide inflexible thresholds of divisibility. The discovery of ecological processes such as habitat requirements for animal species operating at a landscape scale demonstrates the importance of intermediate degrees of divisibility (Lee et al., this volume). Regional and global ecological processes are even less divisible. The management of an entire watershed is an indivisible process, even though the management of situated objects such as trees may be divisible (Franklin, this volume; Naiman et al., this volume). Many of the problems of watershed management, especially issues involving cumulative effects, originate in the difficulties of integrating divisible processes across an entire watershed landscape. The fact that this is fundamentally a problem of integrating institutional processes at different thresholds of divisibility has received little attention. But, as shall be discussed below, attempts to use large landownership units to facilitate integration at the watershed scale have not always met with success on either large public or private ownerships.

Private and Public Goods

Another important dimension of institutional arrangements for regulating ecological processes is the distinction between private and public (or collective) goods (Freeman and Lowdermilk 1981). A good is *private* if its benefits can be captured by the owners and denied to all other members of the community. A private good is one for which the investor as the owner has the incentive to invest because those who do not invest cannot derive benefits (there are no "free riders"). Timber production or home ownership are examples.

A good is considered to be *public* (or collective) if benefits cannot be denied to people who do not invest in producing it. For example, scenery and clean air are public goods because there are no convenient ways of excluding benefits to people who do not help bear the costs of creating scenic vistas or protecting air quality. Fish habitat enhancement and river system planning are examples of public goods at a watershed scale. A rational, calculating individual would choose not to share in costs of fishery enhancement or river basin planning if the benefits from these investments could be captured by others who do not pay for production costs. The easiest way of limiting access to a resource is to adopt institutional arrangements that make it possible to restrict benefits to those who contribute.

However, sustainability requires that future beneficiaries be considered when making management decisions. The most reliable way of eliciting commitments from those who are yet to be born is to ensure that institutions are stable (Firey 1963). Institutional stability can be ensured by honoring inherited institutions such as private property, rights to production, and basic human rights. Rational investors will continue to make commitments that

Table 4.1. Alternative institutional arrangements in watershed management.

Type of Good	Divisibility of Space: High (small scale)	Moderate (medium scale)	Low (large scale)
	1	2	3
Private	Trees Homesites	Individual tree farm Subdivision	Corporate tree farm Private utility
	4	5	6
Public	Silt dam Fishing and hunting access	Fisheries habitat enhancement Community resource management	River basin planning National forest management

yield future benefits as long as they can be assured that essential institutions are stable (Zimmerman 1951).

Divisibility and the nature of goods can be combined in a table showing how they define institutional arrangements. Table 4.1 displays alternative institutional arrangements for regulating ecological processes in managed watersheds. Cell 1 in the table combines high spatial divisibility with private goods. Regulation of ecological processes occurs at a relatively small scale with all the advantages of a market for private goods. Economic incentives can efficiently channel human behavior because (1) users who do not pay can be excluded, (2) necessary credit and technical assistance are accessible, (3) more powerful members of a community cannot monopolize most of the available resources, and (4) sufficient numbers of owners are involved to provide the discipline of competition (Freeman and Lowdermilk 1981, Savas 1977).

Market systems have the advantage of regulating ecological processes in ways that can reduce most of the information flow pathologies. Competition forces accountability and self-monitoring, reducing the chances that a false analogy or ideological commitment will be perpetuated for long. The scale of operations is small and can encourage attention to detail. Longer-term ownership commitments (especially intergenerational institutions that guarantee or require inheritance of real property) can encourage longer observational periods. When ownership and management are combined, there can be fewer problems of managerial detachment and the assignment of responsibility for problems to someone else. Longer observational periods increase the chances that reactions to problems will not be out of phase.

However, land uses such as uncontrolled residential development or speculation in forest or agricultural land involving frequent turnover in ownership can result in reactions that are out of phase, short observation periods, greater detachment, and a tendency to leave the next owner with unsolved problems.

The main disadvantages of competitive market systems are the difficulty in disciplining actions that go beyond ownership boundaries and the emphasis on present benefits (which cause negative externalities) (Savas 1977). Small spatial scale and emphasis on the present can result in a failure to appropriately regulate ecological processes that are larger in scope or more extended in time than the concerns of a landowner. These are problems of institutional structure rather than information processing. One example of landowner behavior having adverse impacts beyond ownership boundaries is the disruption of the ecological functioning of riparian systems caused by erosion and transport of organic and inorganic materials; another is the cumulative impact of small-scale vegetation management on wildlife species that have landscape-scale habitat requirements (Lee et al., this volume). Loss of genetic diversity is an example of a problem originating in emphasis on present benefits.

Attempts to correct for these disadvantages have involved increasing the scale of ownership and ecological regulation, and also changing property rights to incorporate greater responsibility for respecting the rights of others, including the general public and future generations.

In cell 2 (see table), ecological regulation by larger ownership units can provide a scale of operations large enough to absorb some of the costs of meeting public responsibilities (environmental costs can be internalized). Individual tree farm owners generally hold enough land to dedicate some of it to watershed protection, windbreaks, wildlife habitat, and other ecological functions that benefit others in addition to themselves. Residential subdivisions are generally developed at a scale that allows internalization of costs associated with water supply systems, sewage treatment plants, careful road design and maintenance, and dedication of land to open space.

Yet these relatively small ownership units are still responsive to the competitive market conditions that can minimize most of the information processing pathologies. They are large enough to display environmental variation, thus affording opportunities for trial-and-error learning. But they are not so large that one person cannot get to know the land base in detail and monitor its responses to management practices over long periods. False analogies are more readily corrected when monitoring of land management practices does not produce the expected feedback. Cumulative learning can occur when managers have a long tenure. Reactions to ecological events can be phased more appropriately when owners are also managers and can be flexible in their responses to unpredictable or periodic events.

However, undesirable effects that extend beyond ownership boundaries and effects of emphasis on present benefits are still likely to be seen as someone else's problem. Other than institutional arrangements for securing public goods (to be discussed below), there are no effective mechanisms for limiting these effects.

There is a widely shared belief that when it comes to ecological processes, large-scale regulation is better regulation. The incentive to see the undesirable effects discussed above as someone else's problem can be reduced and sufficient capital can often be mobilized to invest in creating future as well

as present benefits. For example, large industrial forest ownerships (see cell 3 in the table) have been justified on the basis of the impersonal, long-term commitments of corporate organizations and the availability of sufficient capital to ensure future benefits and protect the environment. Balanced against these potential advantages are several problems of information flow that accompany larger organizations.

Larger organizations generally require formalized decision processes that take the form of abstract rules. Such standard operating procedures increase the chance that information flow will be distorted by false analogies and inattention to detail (Schiff 1966). The separation of ownership from management increases managerial detachment. Personnel management in large organizations generally involves frequent transfers, thereby limiting the number of years a manager can dedicate to learning a particular land area. Lack of long-term observation can increase the chances of reacting out of phase.

Centralized organizational decisions may also be affected by short-term goals or ideological beliefs that result in a failure to learn how land responds best to treatments. Examples of short-range goals in private forest management include the rapid harvesting of timber to stave off the purchase of a publicly held corporation with high assets but moderate or low profits, or liquidation of assets to pay off short-term loans or bonds used to purchase lands with utilizable resources. Ideological commitments to the principle of private property can blind decision makers to necessary responsibilities of private ownership, including monitoring the effects of management practices.

Institutional arrangements for managing ecological processes providing public goods also range in scale (see cell 4 in the table). Where ecological processes are relatively divisible, subunits of communities provide regulation. Joint family enterprises or cooperatives are examples. The appropriate scale of social organization is determined by the necessity of ensuring that collectivities of beneficiaries will share in paying the costs of management. The cooperation of farmers in building and maintaining a check dam to keep debris from obstructing an irrigation system is an example of a relatively divisible process.

The fact that private owners cooperate to solve the problem of users benefiting without paying is an important feature of many small-scale collective enterprises. Such cooperation becomes increasingly difficult with the increasing size of ecological processes and increasing number of private owners (Savas 1977). Institutionalization of ecological processes, especially as it involves the internalization of conservation ethics, seems to work best at the level of relatively small social organizations where disciplining of behavior is regulated by personal interactions, personal identity, and pride in maintaining a reputation as a sound and respected local citizen (Korten and Klauss 1984). This is clearly illustrated by Smith's (1978) work on community regulation of irrigation systems in Japan.

Like visible private ownership, such small-scale collective regulation can be effective in limiting most of the information flow pathologies. Cooperation can increase the efficiency with which people learn how to regulate ecological processes, since it can facilitate more effective exchange of information among managers and provide opportunities for accumulating a collective memory that can extend observations and better distinguish short- and long-term processes (Chandler 1990). There can still be serious problems of attributing problems to someone else, but collective responsibility can help overcome the human tendency to focus on short-term interests.

Cooperation among a small number of owners increases the chances that management activities will be institutionalized and ensures investors that they can depend on their kin, friends, or neighbors to make contributions in the future. Moreover, exercise of social controls by a local community can eliminate most of the detrimental effects generated by those who refuse to cooperate (Chandler 1990).

The tendency for people to make present commitments to future-referring values is perhaps most developed for collective enterprises at the scale of communities (Firey 1960, Smith 1978, Berger and Neuhaus 1977). Ecological processes of intermediate divisibility (cell 5 in the table) are large enough to encompass one or more watershed ecosystems. Most of the information processing pathologies can be limited where the participants in a process of collective governance are individual or family landowners. Cooperation can capture all the information processing advantages of a decentralized market system while also limiting the tendency to treat undesirable effects and future beneficiaries as someone else's problem.

The social structure of Japanese mountain villages illustrates how watersheds can be effectively regulated when individual ownership is coupled with community resource management. Land is owned by individual families, but decisions on land use are made by the community through local mechanisms of democratic governance. Decisions as to what crops are grown where and when are informed by shared ecological knowledge of the effects of slope, aspect, soil productivity, stability, and moisture, as well as other factors. Communities with prosperous economies and stable populations readily make long-term investments in growing sugi (*Cryptomeria japonica*), tea, fruit trees, or oak trees (as substrate for growing shitaki mushrooms) because they are assured of long-term institutional stability. Literacy, advanced technical training, and an educational infrastructure provide the capacity for accelerated learning of ecological processes. This has enabled some tree and rice farmers to achieve economic and community stability by diversifying resource production to include mushrooms, mountain vegetables, fruit trees, tourism, and miscellaneous value-added wood products. Communities dependent on the production of wood from Japanese national forests exhibited far less resiliency, since their options for land use were limited to the collective national values of wood production, watershed protection, and forest preservation (Lee, unpublished data).

Large-scale collective ownership or regulation of ecological processes (see cell 6 in the table) has long been assumed to be the best institutional ar-

rangement for managing large river basins or watershed ecosystems (Selznick 1949). The United States, Canada, and many other nations have retained substantial areas of undeveloped land in public ownership with the objective of providing public goods in both the present and the future. Retention of these lands in collective ownership has succeeded in providing significant options for contemporary resource use and allocation. Whether they will continue to be as successful in providing public goods is uncertain.

Regardless of these benefits, the large public organizations used to manage extensive ecosystems suffer from the same problems of information flow as large private organizations. When highly bureaucratized, such as the U.S. Forest Service (Kaufman 1960), large organizations can suffer from information flow problems as great, or even greater, than large private organizations.

Reliance on abstract decision-rules, handbooks, and frequent transfer of personnel may develop a manager's mind to the point where it embodies the organization and ensures conformity (Kaufman 1960). But such an "organizational mind" increases the chances that a manager will use false analogies, rely on overgeneralized models, have short observation periods, experience managerial detachment, exhibit out-of-phase reactions, and, often quite appropriately, make attributions of cause for management problems to someone else's decisions.

Large organizations also suffer from a tendency to rely on a sense of mission defined by ideological beliefs (Twight 1983). For almost 70 years, public land management organizations were ideologically committed to eliminating all fires from wildland ecosystems in the United States (Schiff 1962). A more generalized ideological commitment to economic and ecological stability also led public land management agencies to ignore the importance of disturbances and spatial variation in ecological systems (Schiff 1966). A post-World War II commitment to timber production on national forest lands appears to have been motivated by a similar ideological belief in the primacy of wood production (Clary 1986). The Forest Service is now struggling to chart a future that will deemphasize wood production and embrace the primacy of "ecological values" (Franklin 1989; Franklin, this volume). Time will tell whether the Forest Service will simply trade one ideology for another by adopting a commitment to promoting "ecological values," with the consequent limitations on its ability to develop an accurate cognitive map that includes humans as a component of ecosystems.

Conclusions

Since humans are an integral part of ecological systems, watershed management cannot achieve ecosystem sustainability without addressing the problems of human organization. As has been shown by sociological studies for a wide variety of resource management problems, knowledge about ecologically effective forms of human organization is as important as knowledge of biology or hydrology. Yet the science of human organization in ecological systems is far less developed.

This article has coupled two social science approaches that are essential for advancing our knowledge about watershed ecosystem management. Cognitive anthropology can help us understand how people learn to manage complex ecological processes because it provides us with the means for studying how people develop accurate cognitive maps of their environments. An institutional approach to sociology can enable us to understand how and why people will conserve options for future generations when individual rationality would lead them to get as much as they could in the present—and thus to understand why it is not possible to maintain ecological legacies without also maintaining cultural and institutional legacies.

This synthesis of institutional and cognitive analysis yields promising opportunities for future research. To begin with, the generalizations summarized in Table 4.1 need to be reformulated as hypotheses and challenged by empirical research. The most interesting hypotheses involve the possibility that (1) small-scale institutions for regulating ecological processes may have a better capacity than large-scale organizations to overcome information flow pathologies and (2) a hierarchical system of regulation involving local communities as the primary collective governance units may be the most efficient and effective means for institutionalizing sustainable ecological processes, because an ecological identity and conscience are more likely to be products of community life than of regional or national collectivities (Korten and Klauss 1984, Berger and Neuhaus 1977).

The promise of sustainable development embodied in the report of the World Commission on Environment and Development (1987) cannot be realized unless individual initiative is harnessed to serve the purposes of flexible and adaptive management of ecological processes. We have much to learn about the institutional conditions that are best suited to rapid, adaptive environmental learning. The literature summarized in this chapter suggests that large government as well as large private land management organizations may be poorly suited for adaptive environmental learning. Both appear to have been sources of social, economic, and ecological instability. Further study must determine whether smaller and more flexible institutional units are better suited for the rapid, adaptive learning that will be necessary to achieve sustainability, or whether there are ways of restructuring large organizations to serve this purpose.

What we do know with certainty is that sustainable watershed management begins by building ecologically effective human organizations. This fact alone must stand as a centerpiece of a new perspective on watershed management.

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