CHAPTER 10

Case Studies in Ecosystem Management

Back to CD-ROM Table of Contents

INTRODUCTION

To assess the various ways organizations and people come together to manage Sierran ecosystems, SNEP conducted four case studies to examine the efficacy of different institutional arrangements:

- The Mammoth-June case study examines how a single national forest is attempting to implement the new Forest Service policy for ecosystem analysis.
- The Lake Tahoe study investigates a set of institutional arrangements in which agencies and the public have worked jointly for over thirty years to restore and maintain the health of a watershed-lake ecosystem being threatened by urbanization.
- The study of the Mediated Settlement Agreement (MSA) examines a process designed to bring together diverse interests to map and manage the treasured giant sequoia forest type.
- The final case compares the mandates and organizational structures of four institutions, describing how they result in different approaches to land management: the Sequoia National Forest, the Sequoia and Kings Canyon National Parks, the Mountain Home State Demonstration Forest, and the Tule River Indian Reservation.

The summaries here explore the institutional lessons learned from local attempts to cope with the dynamics of ecological and socioeconomic change. The studies represent a modest effort to capture the complexity of issues affecting planning, current management practices, and the means for resolving conflict. They are incomplete in that they do not cover the full diversity of Sierra Nevada issues, but they do provide a reasonable sample of how institutions act and interact to affect ecosystems within the range.

THE MAMMOTH-JUNE CASE STUDY

The Mammoth-June Ecosystem Management Project (MJEMP) of the Inyo National Forest is one of the first attempts in the Sierra Nevada to follow the new Forest Service landscape-analysis policy for ecosystem management. This process is intended to guide national forests throughout California in analyzing capabilities and thresholds of moderate-sized landscapes (e.g., 20,000–50,000 acres) for long-term health and sustainability. A primary goal of these analyses is to develop a desired condition, or a "word-picture" of the landscape as it would ideally be in the future. This would serve to guide the nature and extent of management practices and other land-use activities that may occur into the future.

SNEP chose this project as a case study to review and analyze the potential for this new policy process, as exemplified in the MJEMP, to help achieve health and sustainability of ecosystems on Forest Service lands in the Sierra Nevada. SNEP's primary interest was in evaluating the concept of historic condition and historic variability, specifically, the usefulness and limitations of historical information in determining a desired condition. Further, SNEP critically reviewed the role of public participation in the new Forest Service landscape process. Insight about these and other issues from the MJEMP case study—framed as answers to questions that follow—helps clarify institutional potentials for and barriers to the integration of landscape analysis and ecosystem management into land management of the Sierra Nevada.

1. What is the history of interest in the Mammoth-June area that led to the current landscape analysis?

Lying between the resort towns of Mammoth Lakes and June Lake, Mono County, the 36,000 acres known as the Mammoth-June area (MJ area) have been the focus of use and public attention since the late 1800s. Dense red fir and lush mixed conifer forests blanket gently rolling topography and intermingle with several large flower- and wildlife-rich meadows against a backdrop of rugged cliffs and peaks that form the headwaters of the Owens River. Amid the otherwise steep, rocky, and semiarid landscapes of the eastern Sierra, the MJ area stands out for its abundance of forests, water, and wildlife. These scarce resources are the focus of continuing public controversy over developed versus undeveloped use in the area: grazing, timber harvest, geothermal development, alpine skiing, nordic skiing, wilderness appreciation, scientific study, and ecological reserves.

The Inyo National Forest, which administers nearly the entire area, has long tried to balance the shifting uses and competing public desires while maintaining what it perceived (also changing with the times) to be the integrity of the resources. The current MJEMP is only the latest in a line of formal planning processes and documents—dating back to 1950—that systematically outline and coordinate management objectives for the MJ area. Most recently, the 1988 Inyo National Forest Land Management Plan wrestled with competing desires for development of a large alpine ski area in the MJ area versus wilderness designation. The Land Management Plan left many of the issues unresolved, deferring decisions until a future cumulative-effects study and an environmental impact statement (EIS) analysis were prepared.

The EIS process began as the "Mammoth-to-June Integrated Resource Analysis" in 1990 but, with the release of the draft Forest Service *Regional Handbook on Ecosystem Management*, was changed in 1993 to the MJEMP.

Why was the Inyo among the first of the California national forests to embark on this new process? For several reasons the issues at the MJ area were becoming urgent enough in 1993 to demand imminent decision making. Because a cumulative-effects, or scientifically based, landscape analysis was called for by the Land Management Plan before any decisions could be made, the MJEMP (or something like it) was a prerequisite. Several key Inyo National Forest staff involved in planning, ecosystem management, and management of the MJ area had been deeply involved in developing and teaching the regional Forest Service ecosystem management process. They had the incentive, understanding, and peer and supervisor support to rapidly adopt its use on the Inyo National Forest. Promise of breaking the gridlock for decision making (e.g., over conflicts such as allocating the area for alpine ski development versus wilderness) in this area provided the essential priority at the forest level to fund the MJEMP.

2. How was information on historical landscape condition used by the MJEMP to develop the "desired condition"? How does historical information and its use relate to ecological sustainability of the MJ area?

The concept of historic condition of ecosystems has played a central if controversial role in conservation-biology discourse, especially in ecosystem management and ecological restoration. A central question is whether the condition of a landscape prior to significant human disruption (i.e., a historic condition) is one model, the best model, or the only model for long-term sustainability. Three dominant views in the debate suggest that a desired condition for long-term health and sustainability:

- mimics forest structure and composition of "pre-contact" time (e.g., 1850 or presettlement);
- lies within the natural range of variability, that is, the range of historic conditions that have occurred within a landscape over a relevant historic period;
- is unrelated to historic conditions.

The first two positions require that good historic data are available or can be obtained for analysis.

Workshop participants discussing ecosystem concepts of the Mammoth-June region, Inyo National Forest. (Photo by Constance I. Millar.)

The MJEMP demonstrated, within a landscape containing mixes of montane eastern Sierra forest types in conditions ranging from actively harvested to minimally disturbed old growth, the following key points regarding historic condition:

- Historic information, either about a specific time or about the range of conditions over a historic period, is extremely difficult to obtain or measure accurately within the budgets, time lines, and training of national forest staff. Most of the information obtained is highly inferential; mostly qualitative; localized, and extrapolated from point sources (pictures, a few locations); mostly short-range (as short as a five-year recent record); and mostly shallow in total time-depth. Quantitative data over long times were available on floristics from pollen cores in meadows and on fire frequency from fire-scarred trees and snags, but these provided frustratingly limited spatial resolution. Historic wildlife distributions were the most difficult to infer, being based on estimates of historic forest habitats and estimates of historic use of habitat.
- High-resolution historic information would require local, long-term research projects with interdisciplinary research teams and adequate budgets.
- Lack of detailed historic information, however, forced the MJEMP to proceed with the analysis in a way that may be best even if excellent measures were readily available: The MJEMP used inferences on historic information to guide the *direction* but not the *detail* of what a desired condition might be; that is, to guide the general pathway of change brought about by the interaction of desired ecosystem processes. In other words, the team took a fourth position in the debate over how historic condition relates to desired condition. The team chose not to try to mimic the detail of past structure or composition, nor to build the desired condition from a highly inferred, and perhaps erroneous, range of variability. Instead, the team sought to ensure that historic natural *processes* (e.g., fire, riparian function, water cycles, aquatic functions) would continue or be reintroduced into the MJ landscape and focused less on promoting exact structure or composition that resembled historic condition. The guiding philosophy of the desired condition was that processes in the future landscape were, for the most part, the same ones that operated under historic conditions. The challenge remained to infer or estimate the rates, forms, and magnitudes of these interacting processes.
- The team chose a desired condition that contradicted the historic condition for some resources. For example, the team felt that the continued reintroduction of Lahontan cutthroat trout (a native of east-side streams but not of those in the MJ landscape) was desired, although not historic. Further, the team described a desired future fuels condition that recognized the need to avoid catastrophic fire in the vicinity of the town of Mammoth Lakes. Such a condition would probably require active fuels treatment beyond the historic forest condition on the town side of the MJ landscape.
- The team's use of historic inference to inform and guide but not specifically determine the desired condition takes into account that the present and the future, despite human influence in the ecosystem, are different from the past. Climate change and disturbance due to fire, avalanche, and volcanic eruptions would have created different forest conditions in the present and into the future than the past regardless of what humans have or have not done. Returning an ecosystem to past structure and composition may be highly inappropriate ecologically, given current and future "natural" environmental conditions. A more useful approach, as is being taken in Sequoia National Park, is to try to determine (through models and inferences) what the forest would be like today if suppression and other management had not occurred. An appropriate condition is for ecosystems to be resilient and responsive to the natural change of the present and future. Although costly, historic data placed within the appropriate dynamic models can provide useful information on how to manage a forest for resilience and adaptiveness.

3. What role did "thresholds" play in developing the desired condition in the MJEMP?

The initial planning process for the MJ area, which followed the directions set out in the 1988 Land Management Plan for the Inyo National Forest, called for development of resource thresholds as well as analysis of cumulative effects. The reconstituted MJEMP retained this goal well into the study. As analysis proceeded, however, it became clear that thresholds were being interpreted in two incompatible ways. Eventually, because of the potential for misinterpretation and misuse, the team abandoned both their analysis and their use of thresholds.

One interpretation of thresholds was held by most of the MJEMP team members. These national forest staff are technical specialists trained as biologists, physical scientists, foresters, recreation specialists, or resource planners. They interpret thresholds conceptually as quantitative values that indicate when major and / or rapid changes of state (forest condition, wildlife viability, fish diversity and productivity, water abundance and quality, soil productivity, plant biodiversity) might occur. They maintain that resource thresholds are highly complex and vary with location in the MJ area, season, management activity, adjacent land use, condition of other resources, and changing weather and climate. The team felt that the data it was capable of collecting could not lead to estimation of quantitative thresholds with defensible accuracy.

Another interpretation of resource thresholds was voiced by decision makers on the Inyo National Forest, who viewed thresholds conceptually as management boundaries or limits. To these managers, thresholds represent the best scientific guess at allowable bounds on activities that could be permitted in an area: if a proposed project does not cause a

threshold to be exceeded, then a management action or proposed activity could be considered. As interpreted, thresholds such as these are simple and static indicators that provide information to managers about resource capabilities in an area and define defensible decision space.

After much debate, the MJEMP analysis team rejected the notion that fixed and quantitative management thresholds could be determined or even exist for any resource condition in the MJ area. Team members willingly discussed the conceptual and qualitative nature of resource variation and extremes, and potential consequences of extending beyond these extremes, but they would not stand behind any numeric values that might be interpreted as thresholds. Many feared that such values would become management targets, and that areas might blindly be managed to threshold values. They emphasized instead an adaptive-management approach whereby ecosystem elements would be observed and interpreted as an ongoing process, monitoring intensity heightened if extreme values were approached, and case-by-case decisions made. Despite their inherent limitations, thresholds, or, more appropriately, management standards and limits, may be imperative in some situations. For instance, they may be useful where ecosystems are highly sensitive to minor disturbances, where trends in activities must be limited, where allowed activities are not "in sync" with natural changes, or as reference points upon which change is monitored. Many of these defensible uses of a reference point extend conceptually beyond what are interpreted as "ecological thresholds."

4. What was the role of public participation in the MJEMP? What are implications for public participation in the new Forest Service landscape analysis (ecosystem management) throughout Sierran national forests?

The role of social participation in landscape analysis, as suggested by regional and national Forest Service policy, is different from the conventional and now widely understood National Environmental Policy Act (NEPA) process. In the current Forest Service landscape analysis policy for the Pacific Southwest Region, public participation is encouraged at all steps of the process, although it is not required, and no specific approach is provided. In the case of Mammoth-June, the team organized a series of public meetings, initially to explain the process of analysis and to field questions, then to describe results, and finally to receive input for the desired condition. In all cases, the meetings were conducted interactively with the public, with team members present to show maps and explain data and opportunities made to record public input.

In the analysis leading to a desired condition, no formal appeal process aside from lawsuit is available for the public to challenge proceedings of a landscape analysis. The conclusion by Forest Service policy makers is that this kind of analysis is not a decision-making process; that a desired condition merely elaborates what has already been determined generally by a Forest Plan. The desired condition does not allocate land, nor does it discuss specific management practices or land-use activities that would be permitted or prevented in an area. Rather, the desired condition describes, in ecological, physical, and social terms, the potential landscape conditions that could be met in the foreseeable future to achieve a sustainable landscape.

These assertions were challenged by one sector of the public during the MJEMP. In letters from the lawyer of Friends of the Inyo (FOI), the MJEMP was viewed as a decision-making process that should be subject to the NEPA process. In the MJEMP, the FOI argued, the public had inadequate opportunity to participate and contribute to the desired condition, and no appeal recourse was available to challenge the desired condition. This group felt that certain actions (such as designation of land as wilderness) would be precluded by the desired condition, and that other activities may be obviously promoted (such as mechanical thinning for fuel reduction in a roadless area). Part of this reaction might have been avoided by more public meetings held early in the MJEMP, which would have both clarified the process to the public and opened the team to public input. When more public participation in fact occurred late in the process, conflicts lessened somewhat between the Forest Service and the public. Public understanding heightened, forest staff incorporated public views and ideas, cooperation improved, and tensions decreased at least temporarily. The question about the decision-making authority of the new ecosystem management landscape-analysis policy, especially as described in a statement of desired condition, remains, nevertheless, a challenge for national forests throughout the Sierra Nevada and California.

5. Is investment in ecosystem management adequate to guide the Sierran national forests in maintaining sustainable ecosystems in areas such as Mammoth-June?

The activities needed to achieve ecosystem management are new and challenging, complex, long term, and expensive. Different kinds of knowledge must be brought to what has been taught traditionally to resource managers. Especially important is the need for critical scientific thinking. Necessary but missing from many landscape analyses such as MJEMP is a context of inquiry, experimentation, integrative thinking, and true interdisciplinary (rather than multidisciplinary) synthesis. Although specialists are skilled in conventional collection and interpretation of data, many do not have the critical understanding or experience to perform creative analyses that are needed to answer the new ecosystem questions they are asking. Thus, rather than advancing the understanding of system behavior, process, and interrelationship, they produce abundant new data about pieces of the ecosystem. Investments in intellectual capacity necessary to achieve complex analysis (e.g., formal education opportunities, work time for learning, freedom to train across disciplines, diverse work experiences) are essential but mostly not forthcoming.

Ecosystem management requires not only an experimental approach to analysis, but an experimental perspective in

institutional behavior. Agencies are called to do things very differently today than in the past; this requires risk taking, making mistakes, and adaptive learning. Although the agencies give lip service to this spirit, in effect, it is mostly not felt by individuals and programs or reflected in budgets. The changing national political climate is reflected in rapid swings of policy and emphasis within the agencies. At ground level, these shifts translate into an "on-again, off-again" modus operandi, which is tremendously debilitating. Fears of doing things out of the ordinary, as well as uncertainty about how to conduct innovative analyses, result in the fall-back posture of adopting conventional methods veiled under new titles. All of this played itself out during the MJEMP. By contrast, when internal support was expressed and consistently maintained, the process blossomed.

Forest Service funding that would allow managers in general to adequately plan, assess, implement, and monitor ecosystem management has dropped precipitously just as the need is increasing. Moneys traditionally available for regeneration, restoration, habitat improvement, and resource monitoring came primarily from timber harvest (per the Knudsen-Vanderburg Act); these funds have nearly evaporated on the Inyo National Forest, as in other Sierran regions, as logging activities have decreased. Allocated agency funds for ecosystem management are meager, short term, and inconsistent; many hands reach into a small pot. In some cases, cost-share support from local communities has been successfully leveraged to complete projects. Together, the lack of funding, priority, training, and risk taking make the likelihood of successful ecosystem management low.

6. *What difficulties face a single-institution (Forest Service) technical team in achieving multiple-stakeholder goals of a landscape analysis?*

Several conditions of the MJEMP suggested at first that the landscape analysis might logically be done internally as a Forest Service staff effort. The lands under analysis in the MJ area were within the administration of the Inyo National Forest, technical agency staff representing the major areas under study were available, funding was primarily internal, no land allocations or management prescriptions were to be made, and no environmental analysis (NEPA) was involved. As conceived nationally by the Forest Service and described regionally by the California handbook on ecosystem management, landscape analysis is a technical exercise intended to identify resource capacities, limits, trends, and future conditions. Public participation is encouraged, but no formal process is outlined or required. Projects and treatments, should they be proposed, would come later in an independent process within traditional NEPA scope.

Under closer scrutiny, the MJEMP actually had several components, some of which might not be appropriately confined to analysis by a single-agency technical team. The MJ area has a large and diverse constituency, both of people interested in the area itself and of those concerned about implications for adjacent lands and communities. Further, the role of the MJEMP as a flagship ecosystem management project of the Inyo National Forest meant that it received attention as a pilot process, beyond the implications to a particular area. Public understanding of what ecosystem management actually entails, or how it will be implemented locally, was poor. The relationship of the Land Management Plan to the MJEMP, and especially to land allocations or decisions about the future of the landscape, was unclear. Suspicion of the new process was high.

The challenge to the agency in such a situation is how to coordinate an interactive, adaptive-management process with stakeholders prior to, and concomitant with, the technical team's analysis. Information needs to be brought out early, among the agency staff and constituents and among the different interest groups themselves, about changes in intent since the Land Management Plan, about elements of ecosystem management, and about how and why a landscape analysis would be conducted. The full range of public views and suggestions regarding the current and future condition of the area need to be heard early in the process so that they can be brought into the technical team's work.

The actual scientific work of the technical team belongs to specialists and resource professionals. This too, however, is best conducted as an open process with vigorous input and review from experts outside the team and outside the agency. Because the analysis and interpretation of historic variability are not straightforward, significantly more scientific involvement is needed than if a routine resource inventory were being done. Opportunities for the public to learn from the specialists about technical findings in meetings and workshops, as the MJEMP team held occasionally, are important throughout the process.

The most effective role for the various stakeholders in developing a future condition is less clear. If sustainability were a property robustly described with high confidence and little variability by specialists, then the technical team would properly be the primary author. As it is, however, in situations like the MJ analysis, there is such limited understanding of what conditions (averages, ranges, and temporal variabilities) result in long-term ecological sustainability, such disparity in fact about what is socially implied by sustainability, and such low accuracy in quantitative estimates, that the process extends beyond science and beyond data collection. More appropriately, during the development of a desired condition, the technical team would prepare technical information and analyses, including its best interpretations of long-term capacities and sustainability. The final development of a desired condition, however, is best handled as a mutually interactive, iterative, discursive process among agency staff (decision makers, planners, and specialists) and diverse constituencies (scientists, interest groups, other agencies). This process will challenge all involved to new forms of open communication and will require conscious commitment to a continuing dialogue.

THE LAKE TAHOE CASE STUDY

With a long, science-based history of environmental assessment, property acquisition, restoration. and management, the Lake Tahoe Basin (LTB) provides much information on the role of adaptive management policies in an altered ecosystem. Though it is not a strict parallel for other parts of the Sierra, the knowledge and experience of ecosystem governance may be greater in the LTB than at any other locale in the Sierra or the United States. The experience shows promise largely because decisions are based on the best available ecosystem information and because a broad spectrum of public and private entities have participated.

1. How does this case study demonstrate an approach to defining and understanding an ecosystem?

Ecosystems are complex, difficult to define, and have unclear boundaries. Thus, it is difficult to focus on interrelationships between elements and management needs. Efforts to understand and define the ecosystem of the LTB have been fueled by concentrating on a valued attribute of the ecosystem—the exceptional clarity of the waters of Lake Tahoe. That it is a relatively small watershed and that the boundaries of the ecosystem and basin are the same aided the effort. Although external influences (e.g., air quality) impact the basin, the small scale of the ecosystem aided in understanding the structure and function of its constituent parts. It was also made possible by the availability of three decades of water-quality data—one of the most significant data sets of its kind in the world.

The initial focus on water clarity has motivated efforts to broaden the understanding of the relationship to water quality of wetlands, soils and vegetation, and deposition of nutrients from the air. Water and nutrient flows off the watershed into the lake were understood, early on, to cause decreased lake clarity. A system to classify the land's capability to withstand disturbance was developed in the 1960s. Recently, research has been undertaken to identify the role of atmospheric deposition of nutrients and the biotic structure of organisms within the lake. Wildlife considerations have also been integrated into this system of evaluation.

Recently, there has been increasing focus on the health of the forests in the ecosystem. Between 25% and 40% of the trees in the LTB are dead or dying. This focus is being spurred on by the threat of catastrophic fire and degradation of scenic values in the region. This effort will result in a better sense of terrestrial vegetative and hydrologic processes.

Ideally, our approach to ecosystem management should be based on an overview understanding of the structure and function of all parts of the ecosystem. However, this type of effort will require the commitment of a substantial amount of resources over a long period of time. The Lake Tahoe experience shows how this endeavor can be sustained by focusing on a valued attribute that, in turn, will at least partially illuminate, or provide the basis for dealing with, the structure and function of the ecosystem as a whole. The key to "valuing" the ecosystem is educating one another on the values that exist to some degree in all ecosystems.

2. What role does long-term information play in understanding and managing this ecosystem?

Knowing the rate of LTB ecosystem change places the problem in temporal perspective and assigns the issue an appropriate level of importance. For example, a scientist working with the Tahoe Research Group recently stated (verbally, to the SNEP assessment team) that, in the absence of humans and nutrient introduction from large volcanoes, Lake Tahoe would have taken approximately 400,000 years (from the end of the Pleistocene) to progress to the level of diminished clarity currently found. Thus, the 10,000 years of human occupation have seen the lake progress to a state that normally would have taken roughly forty times longer. (If only the last 150 years of human occupation are considered, the ratio is even more striking.) Though this is an estimate based on a general, but quite substantial, knowledge of lake eutrophication, it places the magnitude of the problem in perspective, assigning a high level of importance to investment in restoration and management.

The past thirty-five years have seen the establishment of an unprecedented water-quality database. Water clarity and related indicators have been monitored by the Tahoe Research Group, creating a continuous record of data that is unparalleled in the Sierra. In addition to its value as a record of water quality, the database enables researchers to evaluate other variables with respect to a single, widely accepted indicator. Thus, issues as diverse as construction, forest management, and erosion control practices may be evaluated, in part, with respect to their impact on water quality. The long term of the database helps establish a relatively high degree of accuracy.

Certain types of historical information, such as water quality and fire interval data, have provided specific guidance about managing the LTB ecosystem. Other types of data may not provide specific guidance but help achieve the understanding of changing ecosystem structure and function that forms the basis for long-term policy and target standards. Historical information also helps isolate the roles of nature and humans, distinguishing between what is under our control and what is not.

Is historical knowledge adequate for ecosystem management of the Lake Tahoe Basin? Clearly there is a need for additional data. For example, more data are needed to develop a comprehensive nutrient budget for Lake Tahoe. Little is known about the basin's forest prior to the arrival of Native American peoples. Similarly, the incidence of fire in prehistoric times is not well understood. Nevertheless, the existing, widely acknowledged record, particularly that of the past thirty-five years, provides a basis for ecosystem management that is scientifically based.

3. What role do ecosystem performance standards play in guiding the basin ecosystem to a desirable future condition?

Pursuant to a bi-state compact, the Tahoe Regional Planning Agency (TRPA) is required to adopt environmental threshold carrying capacities that are necessary to maintain a significant scenic, recreational, educational, scientific, or natural value of the region. The TRPA's Regional Plan must be designed to achieve the thresholds.

Nine standards are evaluated every five years by TRPA (the standards are called "thresholds" in the LTB). In the most recently completed evaluation (1991), only one standard was in compliance. Standards are viewed more as targets to achieve over many years; accordingly, there is an effort not to change the standards, so that a continuous picture of ecosystem performance, and change, can become clear. If a standard is not met over time, the governing institutions can infer that the standards may have been set at unrealistic levels for this ecosystem operating at this juncture in its evolution under this set of human modifications or that restoration and mitigation techniques are inadequate to bring the ecosystem into compliance with the standards. Identifying the standards and setting reasonable levels of performance, based on available concepts and data at the time, are important tools of adaptive management.

Standards also establish a consistent form of accountability for land-use managers and regulatory agencies, as well as an important framework for additional research and monitoring activities. Adopted standards can focus people and institutions on specific parameters, a process that helps to build consensus. Places with great fluxes of tourists often have difficulty achieving and sustaining a sense of community that fosters sustained discourse about goals. At Tahoe, the process of institution building and the setting of performance standards has been responsible, in part, for creating a sense of place and community that is based on an understanding of how the ecosystem works and to what ends it should be managed. Thus community capacity for intelligent and effective stewardship has been forced from private, local, state, regional, and federal components, each of which sees it to its own advantage to participate and cooperate (e.g., casinos and ski areas know the lake and basin attributes are an important part of their marketing advantage).

4. Is the coalition of individuals and institutions able to engage in adaptive ecosystem management?

Adaptive ecosystem management is the ability to use the best available knowledge for manipulation (restoration, management, use, etc.) of the ecosystem; to monitor the effects of that manipulation; to judge whether the effects are contributing to a healthy, sustainable system; and to make appropriate adjustments and adaptations in management and knowledge. This process includes adapting human behavior and knowledge to the sequence of ecosystem states over time. Episodic changes in ecosystem and function—brought about by nature or humans—often produce significant gains in knowledge. This is true of the action to export all sewage from the basin. This action was based on the best technical understanding of the ecosystem at the time, an understanding that said lake productivity (algal growth) was critically linked to the amount of nitrogen moving to the lake from, primarily, septic tanks. A system to export sewage from the basin was constructed, but follow-up monitoring showed the lake still diminishing in clarity. Further research indicated that the disturbance of watersheds released nutrients. This information led to policies that limited land coverage (e.g., impervious surface) in the basin. More recent research motivated by this continuing trend produced the conclusion that the lake was now in a phase in which clarity was limited by phosphorus now that nitrogen loading was diminished. This information was an important reason for increased emphasis on soil erosion control and watershed restoration. In each case, institutional learning and adaptation of behavior occurred.

The use of performance standards, the general sense of the basin's history, and the cooperative interlocking of multiple-level institutions give members of the Tahoe community the capability to monitor and share with one another their perception of changes in the environmental and socioeconomic components of the system. What is more important, the availability of funding has given local agencies and nonprofit organizations the ability to develop and implement projects that address their needs and those of the ecosystem.

Our evaluation suggests that a relatively sophisticated form of adaptive management is occurring in the LTB. Individuals and institutions have established the need for scientific information, have sought the resources for acquiring it, and are prepared to use it as a basis for land-use policies for restoration activities and resource management practices. To date, the courts have consistently upheld the validity of this scientific information, and related concepts, as a rational basis for adaptive ecosystem policy.

The process of adaptive management would be enhanced not only by more coordination of information gathering and interpretation but also by strong advocacy for critical research funding. These tasks could be accomplished by an active science advisory board for the LTB.

5. Is investment adequate to sustain the valued attributes of the Lake Tahoe Basin ecosystem?

Varying degrees of investment will be required in the Sierra Nevada. In some areas, the investment may involve only monitoring and passive management. In others, substantial investments may be needed to restore ecosystems.

At Lake Tahoe, there has been a mixed pattern of private and public uses for more than 130 years. The initial uses were predominantly private (timber, grazing, recreation). Over the past 90 years, more than 85% of the basin has been acquired by public agencies. Nevertheless, urbanization has left its indelible mark—the creation of more than 49,000 subdivided lots and 29,000 acres of developed area. The urbanization of

Turn-of-the-century logging in the Truckee River basin around Lake Tahoe used animals, narrow gauge railroads, and water flumes to haul out logs. Extensive areas in this region of mixed conifer forest had most of the tree cover removed. (Courtesy of Searles Historical Library/ J. Morse.)

the LTB and past resource management practices have fragmented the ecosystem in such a manner that an extraordinary investment is needed to stabilize the system.

During the past fifteen years alone, more than $300 million has been invested in acquisition and restoration activities. A greater investment is still needed to fund soil erosion and watershed restoration projects identified in the region's water-quality plan. These kinds of activities are essential to achieving TRPA's thresholds. The goal of these programs is to reduce almost 50% of the sediment entering the lake.

Investment in knowledge is a subject of both concern and opportunity. It is of concern because the task of managing the Lake Tahoe Basin ecosystem is becoming more difficult as both natural and human processes evolve and intertwine. There are powerful scientific and technical participants in the basin that have demonstrated over the last thirty years that good knowledge is mandatory for guiding ecosystems. LTB science and research have been critical to court decisions supporting management and restoration programs; however, if investment in research continues to diminish, the need to understand and manage will exceed the generation of knowledge. An adaptation to this situation is under discussion as Tahoe organizations seek new combinations of skills to fill the growing knowledge gap. For example, the Forest Service's ecosystem management policy is attempting to bring scientists and managers into more efficient cooperation even as funding for management and research is reduced significantly.

The positive side of our assessment of knowledge investment derives from the unique opportunity at Lake Tahoe to learn from restoration and management projects. The opportunity can be realized if the results of the large investment in institutional formation and cooperation, land-use regulation, environmental restoration, and ecosystem science can be made available, with interpretation, to the constituents of this and

other ecosystems living at some distance from Tahoe. The state's bioregional information center concept, which links the Tahoe experience with worldwide telecommunications networks, leads in this direction, as does the Tahoe–Lake Baikal cooperative education program. The assessment team's judgment is that the three decades of Tahoe experience, if communicated effectively, can be of immense value for all types of ecosystem management projects internationally. The educational potential is far from being realized at present.

There is also a need to increase management funding. Such funding is needed to take the major steps to reduce fire hazard and nutrient flux to the lake while restructuring the forest so as to sustain an efficient stewardship program.

The current level of public investment is inadequate. Federal funding for both acquisitions and control of soil erosion has dropped sharply. There is a decrease in federal investment for management of more than 70% of the basin's land base. State investment has remained stable but far below needed levels. For example, the TRPA "208" Plan anticipates an annual investment of $9 million from state sources for soil erosion control alone; currently, only a portion of this total is being made available.

The magnitude of the need is extraordinarily large. During these difficult fiscal times, the prospects of long-term funding are unknown. It is clear that both public (e.g., bond acts, budgetary appropriations) and private investments (e.g., redevelopment programs) will be needed, because neither sector can afford to do these activities alone. Additionally, market mechanisms such as mitigation banks and transfers of development rights should be more fully developed to generate revenues.

The amount of investment will depend upon the value—economic and otherwise—placed on this resource. The LTB economy ($2 billion visitor-serving economy involving 20,000 jobs) is inextricably linked to the health of Lake Tahoe and its surrounding forests. For the rest of the Sierra Nevada, it is very important to understand the problem of investment distribution; it costs many times more to restore an ecosystem than to prevent degradation.

6. How was ecosystem management institutionalized in the LTB?

The institutionalization of the LTB resource management process began in the early 1950s with the efforts of small organizations, foundations, and individuals, and led, within a decade, to task forces sponsored by both state and federal governments. During this period, federal leadership (reflecting federal legislative mandates), advocacy organizations, and elected federal and state officials played a prominent role in developing approaches for ecosystem management at Lake Tahoe. Understandably, local governments were concerned about losing their jurisdiction over land-use matters. Since 1969, a number of public and private institutions have been formed to assist in the management of this ecosystem. Due to the nature of resource degradation, they reflected a need to sustain ecosystem management activities within this ecosystem over a long period. Specifically, institutions were created to implement long-term monitoring and research; a regional planning approach was developed that matches ecological boundaries and transcends existing political boundaries; and resource management agencies were designed to acquire, restore, and manage land for ecosystem purposes.

First, the process of ecosystem management at Lake Tahoe required developing or adapting organizational structures and approaches to ecosystem activities. For example, TRPA, a bi-state agency, was created to develop and enforce land-use standards. The Lake Tahoe Basin Management Unit, carved out of three national forests, was established to manage all U.S. Forest Service lands within the LTB. The state of California created the Tahoe Conservancy to administer resource protection programs. In the private sector, nonprofit organizations were created to support ecosystem efforts.

Second, the ecosystem process places a premium on cooperation: sharing of data, cooperative project planning and implementation, and the provision of funds.

Third, there is an emphasis on public-private collaborative efforts such as the Tahoe Truckee Regional Economic Coalition and the Tahoe Coalition of Recreation Providers. These organizations recognize the interdependency of economic and environmental concerns and the need for both public and private sectors to combine resources.

Last, there is a growing recognition of participatory and consensus processes for moving initiatives forward—a by-product realizing that both sides may lose more than they gain through litigation. Certainly the overall approach is controversial in some quarters. There are still concerns about infringement of property rights and about litigation. There are concerns that the environment is emphasized to the detriment of the economy. However, the current form and processes of ecosystem management at Lake Tahoe provide some optimism that institutions may be able to deal with the uncertainty, complexity, and cost and time requirements involved in this approach.

THE MEDIATED SETTLEMENT CASE STUDY

Giant sequoia *(Sequoiadendron giganteum)* is known worldwide as an awe-inspiring species of immense size, longevity, and attractive form. Because of the extraordinary range of values and adaptability of the species, giant sequoia has been successfully planted beyond its native range in northern and southern California, Oregon, New Zealand, and Europe. Limited in natural distribution to approximately seventy distinct groves concentrated in the southwestern part of the Sierra Nevada (figure 10.1), giant sequoias are widely recognized for their social, economic, and scientific importance. Since the

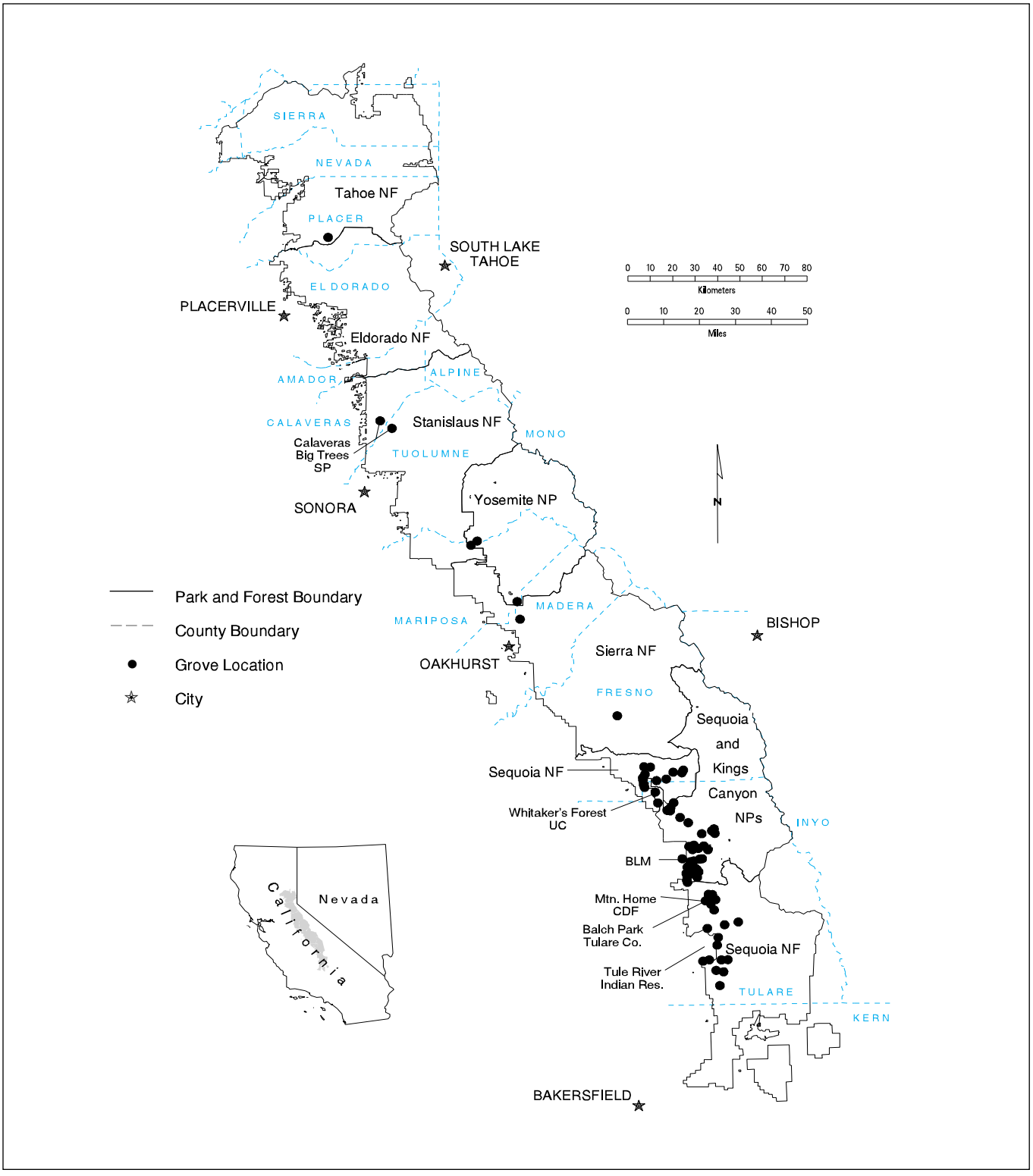

FIGURE 10.1

Locations of giant sequoia groves in the Sierra Nevada. (From volume II, chapter 55.)

late 1800s giant sequoias have been a focus of local, national, and worldwide attention. Giant sequoia trees have provided wood products, served as scientific resources (tree-ring and fire scar records), major tourist attractions, and a source of spiritual renewal. Increasingly, giant sequoias have been protected in various public ownerships (national parks, national forests, a state and county park, a state demonstration forest, and a university forest).

In February 1988, the Sequoia National Forest published the Land and Resource Management Plan (LMP) and Record of Decision documenting land allocation and management decisions for the forest. The LMP was administratively appealed to the chief of the U.S. Forest Service by twenty-one appellants. Giant sequoia management was only one of many appeal issues. Four appellants interested in wild and scenic rivers and the California Department of Fish and Game resolved their issues through the appeal process. One appeal was dismissed, leaving fifteen appellant groups, including intervenors, with substantial issues on appeal. The claims and issues of these remaining parties were so disparate that the Forest Service elected to use formal mediation and hired a professional mediator. The resulting 1990 Mediated Settlement Agreement (MSA) specified terms of agreement on, among other issues, grove mapping and the future management of giant sequoia on the Sequoia National Forest.

1. Why does the SNEP report contain a special section relating to giant sequoia and the Mediated Settlement Agreement?

In 1992 the United States Congress considered two bills (H.R. 5503 and H.R. 6013) relating to an ecosystem study of the Sierra Nevada. H.R. 5503 was passed, authorizing the study. The Sierra Nevada Ecosystem Project Steering Committee's charge to the project scientists called for "an examination of the Mediated Settlement Agreement, Section B, Sequoia Groves, and recommendations for scientifically based mapping and management of sequoia groves." We reviewed the Mediated Settlement Agreement documents and the mapping of the groves and addressed giant sequoia management and sustainability issues.

2. How did the mediation process work?

A professional mediator was hired and gained the acceptance of all parties for beginning a negotiation process. The process began in February 1989 and ended in July 1990 with a Mediated Settlement Agreement. The purpose of the negotiations was "to resolve issues and concerns raised in the appeals of the Sequoia Forest Plan through mediated settlement involving appellants, intervenors and the Forest Service to the mutual satisfaction of all the participants" (Exhibit C, page 1, MSA). Protocols for the negotiation process were established with detailed expansion for each section; purpose and goals, structure for the negotiation process and the decision-making process, among other protocols, were detailed at the beginning.

Most of the appellants participated in the mediation, although not all of them completed the process. Much of the agreement deals with various issues of the forest LMP. Our review focused on Section II B of the MSA, Giant Sequoia Groves. The agreement terminates with formal revision of the forest LMP.

3. Was the Mediated Settlement Agreement an effective tool for resolving conflicts?

The MSA was a means for resolving an otherwise irreconcilable conflict among the Forest Service, environmental, recreation and commodity interests. The agreement applied only to the Sequoia National Forest; however, in 1992 uniform policies for giant sequoia were extended to all of the national forests with naturally occurring giant sequoia groves (Sierra, Sequoia, and Tahoe National Forests) through Regional Forester Ronald Stewart's direction and a subsequent 1992 proclamation by President George Bush. The goal "shall be to protect, preserve, and restore the Groves for the benefit and enjoyment of present and future generations." The MSA specifies a process for the identification of grove administrative zone and grove influence zone boundaries. Grove-specific management plans are required. Permitted activities within the groves and grove influence zones are listed.

The mediation process appears to have been a practical approach to resolving the giant sequoia conflict of 1988. Mediation allowed for (1) participation and sharing of information by the key players; (2) agreement on objectives; and (3) agreement on a process for resolution of key issues. The process was accepted by virtually all concerned parties as a compromise that would allow forest management to proceed in "full view" of the appellants while more difficult questions were being considered. It addressed the most obvious and immediate threats to the groves (e.g., logging of associated whitewoods, fuel hazard reduction). Means of achieving long-term preservation were left for later resolution through participation by interested parties and planning in accordance with NFMA (National Forest Management Act) and NEPA (National Environmental Policy Act).

4. Are there substantial deficiencies in the MSA that interfere with necessary protection, including management activities?

Implementation of the MSA process was hampered by the language of the agreement, which requires concurrence from all parties for any amendment to the MSA. As unanticipated issues arose, some of the signatories were not responsive, thus frustrating MSA's specified amendment process. The MSA lacks provisions for handling basic issues of public safety, maintenance of existing easements, and other uses in the groves. The Forest Service has since worked out an administrative process for handling the maintenance issues satisfactory to the active MSA signatories but not specifically provided for in the agreement. It is important to anticipate the whole range of issues during the negotiation process.

The MSA is a combination of precise directions (e.g., grove administrative boundaries are defined as 300 or 500 feet outward from the tree-to-tree perimeter line) and general language stating management objectives without specific direction (e.g., "The objective of fuel load reduction plans shall be to preserve, protect, restore and regenerate the Giant Sequoia Groves without unnecessary damage to any old growth tree in the Grove"). Specifically, there were no definitions of such terms as *protect*, *preserve*, *restore*, or *original condition* or direction on how they were to be accomplished, thereby giving the Forest Service considerable flexibility, as long as commercial logging was kept out of the groves. Success in accomplishing agreed-on objectives will require a strong participatory process and trust building.

Mediation provided a way of negotiating resolution of disagreement, not necessarily of sharing or implementing the best science. Despite these problems, the parties, including the Forest Service, have generally been able to work within the agreement. Annual reports document steady, slow progress in accomplishing the tasks specified in the agreement and confirm agency commitment, improved communications, and strong participation by some of the signatories.

MSA Summary Conclusions

- Despite operational problems in implementing the giant sequoia section of the MSA, we conclude that the mediated settlement approach is a reasonable means of conflict resolution for controversial resource management issues. This negotiation identified the importance and difficulty of resolving conflicts among values, process, and science.
- The MSA recognized the need for research, which perhaps gave impetus to the formation of an interagency research group. The Giant Sequoia Ecology Cooperative has been formed by the Forest Service, National Park Service, National Biological Service, and California Department of Forestry and Fire Protection and is waiting for University of California signature. This group has the potential of becoming the scientific core for developing specifics for an adaptive management approach to protect, preserve, and restore the groves.
- Unless the Giant Sequoia Ecology Cooperative can be strengthened and funding ensured, there is little likelihood an adaptive management program will be developed and carried forward that will ensure the protection, preservation, and restoration of the groves. Members must be commited to work together in a continuous collaborative effort of research, planning, execution of management activities, and evaluation of results. Alternative funding sources to augment limited federal and state funds should be explored.
- The MSA work has proceeded slowly, at times testing the workability of the agreement. The active participants have found practical solutions to overcome the few MSA structural deficiencies; mapping is completed; work on grove management plans and a cooperative prescribed fire are planned for 1996. Other MSA work needs to be accelerated.
- The agreement has provided an opportunity for the signatories to fully participate with the agency as plans are developed. Through the MSA they have an increased role in the activities from planning to execution. The issue of requiring unanimity of signatories for formal amendments is yet to be resolved. Not all signatories remain active in the process.
- Interested parties not participating in or not affiliated with MSA participants were not accommodated in agreement provisions. The Forest Service has responded to this potential problem by keeping all interested parties informed of grove management activities.
- The agreement seems to provide the flexibility necessary to develop a scientifically supportable plan for giant sequoia management in spite of the lack of a comprehensive scientific basis in developing the MSA. Of equal importance, it has provided a structure for communication among otherwise adversarial parties and provided a mechanism for increasing stakeholder involvement in key discussions and decisions.
- The MSA has helped to restore trust between the active participants and the Forest Service. This cooperation has probably been facilitated by their realizing that the only alternative may be statutory direction or more litigation.
- The MSA provided rationale and impetus for establishing a Giant Sequoia Management Program for the Sequoia National Forest where none had previously existed.
- The MSA must be recognized as only a beginning step in developing a comprehensive strategic plan for each grove. The interested parties, the agencies, and the Giant Sequoia Ecology Cooperative must move quickly toward this planning goal, incorporating the best appropriate science, even in the face of declining budgets.

Grove Mapping

Mapping of giant sequoia groves may appear to be a simple task but in fact is enormously complicated by irregular patterns of naturally occurring giant sequoia trees, rugged topography, and the importance of identifying the full area of ecosystem influences for each grove. The entire influence area must be considered for long-term giant sequoia sustainability.

1. How were the groves mapped?

Grove mapping within the Sequoia National Forest began in 1992 and was completed by the Forest Service in 1995. MSA procedures were followed. The mapping of the boundaries employed a three-step approach; a perimeter line was estab-

lished joining all the outermost trees of a grove; next, a buffer of either 300 or 500 feet (specified in the MSA for each grove) was added to the perimeter line. This combined area became the grove administrative boundary. An additional 300 to 500 feet (MSA-specified) were added to the administrative boundary to define the grove influence zone. Field review of all grove boundaries by the MSA boundary team is still in progress.

The project used special aerial photos with expert photo interpretation followed by field verification. Final grove administrative boundaries were posted and traversed using a global positioning receiver. Grove influence zones were derived in the GIS by adding the MSA-prescribed distance to the administrative boundary, except when otherwise provided in the MSA. Final maps were produced from the digital database.

2. Is the mapping adequate for grove-specific plans?

Our examination of the mapping process raised questions with respect to the grove buffers and influence zones. The assignment of a buffer of either 500 or 300 feet beyond existing giant sequoias appears to be arbitrary rather than science-based. The MSA provides no justification or basis for specified buffer widths. We can only conclude that the mediation process did not allow for resolution of this issue using ecologically based criteria.

Although the giant sequoia grove mapping has been completed, we believe ecologically based influence zones incorporating hydrology, fuels, and other landscape-scale considerations should be a high priority in the preparation of individual grove management plans. Incorporation of available ecological knowledge is critical and should be supplemented with new understanding in defining the influence zone necessary to ensure the long-term health of the groves. This issue should be addressed by the Giant Sequoia Ecology Cooperative.

Mapping Summary Conclusions

- The mapping as specified in the MSA has been completed; there remains some field verification by the MSA grove mapping team. The mapping included appropriate technology to produce accurate maps and provide permanent boundary reference. Mapping took longer than anticipated and produced some unexpected results: (1) several of the groves are more extensive than previously thought; (2) one new grove, not previously described, was identified; (3) two groves previously named do not exist; (4) groupings of isolated trees suggest recognition of four additional groves.
- The MSA mapping that established grove influence zones should be considered an interim step until ecologically based grove influence zones can be established for each grove.
- The Giant Sequoia Ecology Cooperative should be assigned the task of developing specific, science-based criteria for defining grove influence zones.

Management and Long-Term Sustainability of Giant Sequoia Ecosystems

Early logging activities proved to be largely uneconomic and were followed by protection of the sequoia groves for the better part of a century. Protection was accomplished through suppression of potentially destructive fires and public acquisition of both logged and unlogged groves. The late 1960s brought recognition of the importance of periodic disturbance to giant sequoia ecosystems. Experimental, and later operational, burning was accompanied by a variety of research projects that documented the importance of fire (including locally hot fires) to sequoia regeneration, forest structure, nutrient cycling, and fuel reduction. Other research documented the historic role and frequency of fire as well as the effects of nearly a century of fire suppression on forest structure and fuel accumulations.

1. Is the long-term sustainability of giant sequoia ecosystems dependent upon public acquisition of additional groves?

There is no compelling evidence to conclude that the long-term sustainability of giant sequoia ecosystems, as a whole, depends on acquisition of the groves now in private ownership. However, public acquisition from willing private owners might be desirable to provide additional public recreation opportunities, preserve specific ecological features unique to particular groves, and increase the public agencies' ability to manage grove areas already in public ownership. The National Park Service and Forest Service collectively manage more than three-fourths of all grove area. In addition the California Department of Parks and Recreation, University of California, California Department of Forestry and Fire Protection, Bureau of Land Management, Tulare County, and Tule River Indian Reservation manage a total of 14%, leaving about 10% of grove area in private ownership.

2. What are the greatest threats to long-term sustainability of giant sequoias and their ecosystems?

There is evidence suggesting that inaction is currently the most significant threat to giant sequoias, the groves, and their ecosystems. Historically unprecedented fuel loads in most of the groves increases the chances of catastrophic wildfire. High-intensity wildfire is increasingly likely to preempt future management options.

In August 1987, a lightning-ignited wildfire swept into the Redwood Mountain Grove (Sequoia National Forest and Kings Canyon National Park). The fire intensity caused scorching or burning of the crowns of large pines, firs, and even monarch giant sequoias, killing the trees. The fire was successfully contained when it burned into an area where fuel reduction by prescribed burning had been completed.

Many other agents may affect the groves. Annosus root rot can weaken giant sequoia resistance to windthrow. Air pollution (ozone) effects on giant sequoia seedlings and ponderosa and Jeffrey pines are of increasing concern, especially in the southern part of the range. More sugar pine trees are succumbing to white pine blister rust, thus changing the mix of associated species in giant sequoia groves.

The strong public interest must be nurtured by all interested parties through sharing of information, issues, and management plans affecting the groves. Public understanding and support are an essential part of future management strategies for the groves.

3. Is there a sufficient research base to support an adaptive management approach leading to long-term sustainability?

In recent decades much has been learned about the history, ecology, and genetics of giant sequoia ecosystems and the effects of various management practices on them. Tree-ring records have provided detailed understanding of the paleohistory of climate, fire, and forest dynamics for selected groves. Ecological studies have improved understanding of the effects of fire and fire suppression on regeneration, forest succession, and nutrient dynamics. Studies of associated fauna, pathogens and disease, and the effects of human impacts (trampling, air pollution, and fire suppression) have provided insight into the functioning and sensitivity of giant sequoia forests.

At the same time, the various agencies and entities charged with managing giant sequoia have implemented an assortment of management strategies from which there is much more to be learned. Nevertheless, there remains considerable uncertainty regarding the long-term consequences of alternative future management scenarios. For example, we are uncertain what the long-term effects of various treatments such as prescribed burning or silvicultural prescriptions (alone or in combination) would be on the sustainability of the forest. This uncertainty, together with the great emotional value placed on these magnificent forests, has focused attention on the appropriateness of recent management activities. As the agencies develop future restoration and preservation programs, utilization of all available sources of information, including identification of successes, failures, and findings of past actions will be essential. The research base is sufficient to prepare grove management plans and begin some management activities (e.g., fuel reduction), but scientific resources are presently inadequate to provide the monitoring and develop the additional understanding necessary for a comprehensive adaptive program leading to long-term sustainability.

4. What is meant by adaptive management?

Our present knowledge of grove restoration and conservation is imperfect, meaning that grove managers must have the flexibility to change their practices as knowledge increases. The variety of lands, conditions, and policies represented by the various giant sequoia management agencies provide opportunities for utilizing varying combinations of fire and silviculture. Because we do not fully understand the long-term effects of differing fire regimes or silvicultural practices (and combinations thereof) on these forests, we must learn as we go. The concept of adaptive management, by which careful monitoring of the effects of management actions improve the understanding of those actions and thus improve the management program, should be an integral part of future management strategies. Continuation of management actions (including no action) without documentation of and learning from those experiences is simply unacceptable.

5. What should the future strategy for long-term sustainability include?

The lack of detail in the MSA regarding specific actions to ensure the long-term protection and preservation of giant sequoia is a major concern. The new knowledge needed to guide giant sequoia management will grow rapidly if the various land management agencies cooperate in management planning and research and compare the results of their various management practices. The recent establishment of a giant sequoia specialist position on the Sequoia National Forest and of the Giant Sequoia Ecology Cooperative are good beginnings. They need to be strengthened and institutionalized. There is increasing concern that the combined resources of all involved agencies, interest groups, and individuals may be inadequate for the task, especially with declining agency budgets for both research and management. Alternative funding mechanisms must be found, and agencies must commit a continuing level of research and management resources adequate for a viable program. We judged both commitment and resources adequate to support development of a strategic management plan for the groves but woefully short for the interagency-university cooperation so necessary for meaningful progress in grove management.

That the MSA was written specifically for the Sequoia National Forest does not lessen the importance of the giant sequoia groves on other agency lands or the need to include all giant sequoia lands in designing future management strategies. Similarly, because of the wide differences in ecological, institutional, and social conditions represented by the groves, it must be recognized that there is no universally correct strategy, or "right answer." The need to address these differences and to test management concepts justifies multiple strategies and approaches.

ECOSYSTEMS UNDER FOUR DIFFERENT INSTITUTIONS

Certain attributes of institutions greatly influence land management. The purpose of this case study is to compare four public institutions in the southern Sierra Nevada to under-

stand the degree to which two attributes—the institution's original mandate and its organizational structure—influence their patterns of ecosystem management. The institutions are a national forest (Sequoia National Forest), a state forest (Mountain Home State Demonstration Forest), a national park (Sequoia and Kings Canyon National Parks, two parks but managed as one administratively), and an Indian reservation (Tule River Indian Reservation). Although these four institutions manage comparable ecosystems, their unique organizational characteristics, histories, and operating rules, in combination with their different mandates, have produced different patterns on the landscape, different mixes of benefit flows, and different levels of conflict. We suggest that the present landscape pattern associated with each institution, and the probable direction of these landscape patterns, can be best accounted for by the interaction between internal organizational characteristics and institutional mandates, rather than by biophysical endowments or scientific principles of land, timber, forest, or ecosystem management. The degree of organizational centralization, the linkages between resource science and resource management, the criteria used for budget allocations, the means for ensuring public accountability, and the degree of planning and management flexibility are key factors that influence the different social and ecological effects of these four institutions.

The challenges of maintaining ecosystem integrity are compounded by the recognition that resource management and stewardship efforts based on the "island-in-time" self-contained reserve model are inadequate to ensure resource preservation or conservation, because significant impacts on areas within a reserve arise from outside it and management regimes within a reserve affect those aspects of an ecosystem that lie outside it. Examples of such "porosity" include air pollution, fire, visitor use, and in some cases sedimentation and changes in hydrologic regimes resulting from upstream management activities. Accordingly, the case study also examines factors that contribute to the ability of public land management institutions to respond to increasingly complex and interdependent social, political, and ecological environments while simultaneously maintaining their legitimacy and the integrity of the ecosystems within their jurisdiction. Tight feedback loops between responsible research and resource management, high levels of institutional legitimacy and public trust, and active interorganizational coordination positively affect institutional performance under the increasingly porous and complex conditions faced by all public forest owners in the Sierra Nevada.

1. What are the origins of the four institutions, and what ecosystems fall within their jurisdictions?

The Mountain Home State Demonstration Forest was purchased by the state of California in 1946 from the Michigan Trust Company. It is administered by the California Department of Forestry and Fire Protection (CDF). The Fresno-Visalia community organization Native Sons and Daughters of the Golden West was instrumental in lobbying the California legislature to purchase the tract to preserve the giant sequoia *(Sequoiadendron giganteum)* groves it contains. Giant sequoia preservation was also one of the reasons for creating the Sierra Forest Reserve in 1893, from which the Sequoia National Forest was formed in 1908, and for reserving in 1890 the two sections and four townships that formed the nucleus of Sequoia and Kings Canyon National Parks. The Tule River Indian Reservation, established in 1873, is located in southern Tulare County. More than nine Californian tribes speaking different languages were relocated here from a much larger region; consequently, only a few of the culturally significant areas for the tribes are located within the reservation.

The jurisdictions of these four institutions have similar ecological characteristics. The Sequoia National Forest and Sequoia and Kings Canyon National Parks encompass lower-elevation oak and grass woodlands, mixed conifer and true fir belts, and substantial areas above the timberline. The Tule River Indian Reservation extends from oak and grass woodlands up through the mixed conifer and true fir belt. The Mountain Home State Demonstration Forest is restricted to the mixed conifer belt. Giant sequoia groves are located within the boundaries of all four institutions. This study focuses primarily on resource management strategies and issues related to the mixed conifer belt.

2. What are the mandates of the four institutions?

Although the jurisdictions of the four institutions encompass relatively similar ecosystems, their legislative mandates differ significantly. The Mountain Home State Demonstration Forest is a "multiple use forest, primarily for public hunting, fishing and recreation" (section 4426, chapter 1496 of the *Statutes of the State of California*). The noncommodity focus of this multiple-use mandate differs from the multiple-use mandate of Sequoia National Forest, which gives equal weight to commodity and noncommodity values. The original purpose of the Sequoia and other forest reserves, as described in the 1897 Organic Act, was to "preserve and protect the . . . reservation," to secure "favorable conditions of water flow," and "to furnish a continuous supply of timber." The 1960 Multiple Use Sustained Yield Act expanded the commodity-oriented mandate of the Forest Service to include outdoor recreation, range, wildlife, and fish, in addition to those purposes set forth in the 1897 legislation.

The initial legislation establishing Sequoia National Park called for protection of the natural features within its boundaries. Consequently, military troops were used to protect the park from illegal activities such as grazing, logging, and trapping, while, in the Sierra Forest Reserve, mining, grazing, and logging were allowed to continue. In contrast to the commodity and multiple-use orientation of the Forest Service, the 1916 legislation establishing the National Park Service states that the Park Service's purpose is "to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of same in such manner and by

such means as will leave them unimpaired for the enjoyment of future generations." Unlike the other three institutions, the Tule River Indian Reservation emphasizes the sovereignty of those living within its boundaries. Its mandate specifies no particular resource management objective.

3. How has the organizational structure of the Mountain Home State Demonstration Forest affected the interpretation of its mandate, the landscape, benefit flows, and conflict levels?

The management of the Mountain Home State Demonstration Forest is characterized by a relatively small staff, for the land area managed. The staff has been in place long enough to possess localized site-specific knowledge, and this, combined with decentralized decision making, enables them to experiment with, monitor, and evaluate different forest management techniques and to engage with non-CDF researchers to conduct research. The decentralized organization of the forest administration promotes an active research program consistent with the purpose of a demonstration forest.

Unlike the national forests, where incompatible uses such as timber production and recreation can be practiced on widely separated areas, at the Mountain Home State Demonstration Forest all multiple-use objectives must be met from a relatively small land area. Consequently, the giant sequoia groves and camping facilities constitute a preserve/recreational forest, while the adjacent and surrounding non-sequoia forest is managed as an uneven-aged production forest. Grazing permits are not issued because of incompatibility with recreation and to allow historically overgrazed areas to regenerate. Timber harvests are planned to minimize visual impacts by using only single-tree and small-group selection harvests. Clear-cutting is not practiced for aesthetic reasons, and harvest intervals have been increased from 15–20 to 30 years to minimize harvest-related forest damage. Annual recreational use of the demonstration forest has increased from 3,000 visitors in 1963 to close to 40,000 in recent years. A combination of tempered harvesting practices, outreach and education efforts, and the short two-week public comment period required under the Timber Harvest Plan limit public controversy and conflict to low or negligible levels.

Preservation of old-growth giant sequoia groves, the demonstration forest's mandated emphasis on recreation, and sustained yield production forestry in non-sequoia areas have produced a mosaic of differently managed and used patches within a relatively constrained geographical area. The forest is extensively roaded; there are no large intact landscape units. Riparian areas and meadows are in better condition than they would be otherwise due to the ban on stock grazing. The decentralized organization of the forest administration has provided the local decision-making autonomy necessary for establishing and maintaining feedback loops between resource science and resource management. Although the forest administration staff do not have the capacity to conduct research themselves, they successfully compensate for this by contracting with other agencies and universities.

4. How has the organizational structure of the Sequoia National Forest affected the interpretation of its mandate, the landscape, benefit flows, and conflict levels?

The Sequoia National Forest is part of a strongly hierarchical organization. The forest staff follow centrally mandated and externally legislated standardized planning procedures that leave relatively limited opportunity for local-level planning innovation and provide few incentives for intensive monitoring and evaluation of the impacts of resource management plans other than to ensure that legal stipulations are fulfilled. Staff members of the Sequoia National Forest are more frequently transferred than those of the other institutions in this study. At the forest level, administrators and staff have minimal control over funding for research or generation of research questions. With the exception of management-oriented administrative studies, forest staff do not conduct scientific research, although they do participate with Forest Service Research (a separate branch of the agency, with a broad mission beyond resource management and the bounds of national forest lands) when research projects occur on the forest. Relative to Sequoia and Kings Canyon National Parks and Mountain Home State Demonstration Forest, there has been less opportunity to integrate research on local conditions with resource management. Except for fire protection, the majority of funding for forest management activities is tied to commodity production targets (including recreation). Although mechanisms exist to enable fire managers to plan and conduct prescribed burns to promote noncommodity ecosystem values, they are generally not well funded. Commodity orientation of fire programs and funding priorities has constrained the ability of forest managers to effectively use fire as a resource management tool to achieve non-commodity-driven resource values and conditions. The ecological effects of fire on other resources is increasingly emphasized at the national level in the agency, and its effects are gradually being felt locally.

These landscape effects of the multiple-use mandate reflect the influence of the agency's strongly centralized organization, which results in a relatively lower degree of local decision making, reduced opportunities to integrate local research and resource management, and stronger linkages between funding and commodity production. Until the 1950s the primary uses of the Sequoia National Forest were extensive watershed protection, wilderness study and classification, grazing, low levels of hydroelectric development and mining, some logging on the western slopes of the forest, and recreational use. In the 1950s the Forest Service began an extensive timber harvesting program that focused on sustained-yield timber production in some areas and in other areas sought to integrate timber production with other multiple-use land-management objectives. By the late 1970s some stands had become understocked. In response to these forest conditions and to other external pressures, management of the forest shifted to extensive clear-cutting and a shortened

cutting cycle (from 150 to 70 years). This accelerated short-rotation timber harvesting program continued through the mid-1980s. During this same period, the Forest Service, aware of the ecological importance of giant sequoia groves, acquired adjacent groves, excluded groves from timber management goals, and established a four-class grove classification system with acceptable management activities for each class. Although the shift to short-rotation clear-cutting was silviculturally sound, inadequate investment in postharvest site preparation and reforestation as well as harsh site conditions created other problems. By the mid-1980s public concern about clear-cutting and other environmental consequences of the timber harvesting program and the threat that harvesting in and adjacent to giant sequoia groves posed to that species, led to twenty-two administrative review appeals challenging the 1988 Forest Land Management Plan and the supporting environmental impact statement. The Forest Service's response to the appeals led to a series of mediated negotiations that culminated in the Mediated Settlement Agreement (see the Mediated Settlement Agreement case study in this chapter for discussion and analysis of this agreement and related giant sequoia management issues).

Grazing on Sequoia National Forest is regulated by annual permits for specific allotments. The Forest Service is now under pressure to revise its grazing policies due to concern about possible range deterioration, the adequacy of existing efforts to monitor range condition, and the timing of grazing permits.

More people visit Sequoia National Forest than the adjacent Sequoia and Kings Canyon National Parks. In order to accommodate the growing recreation activity within the forest, campground management and other recreational activities are contracted to private firms through special-use permits.

The Sequoia National Forest is also involved in formal and informal interagency coordination. Recently, the Sequoia National Forest administration was instrumental in organizing the Giant Sequoia Ecology Cooperative. The cooperative, formed soon after the 1992 symposium Giant Sequoias: Their Place in the Ecosystem and Society, held in Visalia, California, is an interagency response to public controversy over management and regeneration of large giant sequoias and common agency recognition of the sparse scientific basis for giant sequoia management. The cooperative facilitates the coordination and sharing of research related to giant sequoias among the member institutions. Ideally it will combine the strengths of each member institution in a manner that strengthens the linkage between resource scientists and resource managers and improves public accountability of the participating agencies vis-à-vis sequoia management.

In summary, the management of Sequoia National Forest has been characterized by fire and watershed protection, intensive and extensive timber harvesting and associated road construction, continued grazing, and high levels of recreational use. This reflects the multiple-use mandate of the Forest Service embodied in the 1960 Multiple Use Sustained Yield Act. However, the landscape effects of the Forest Service's mandate have also been shaped by the strongly centralized organization of the service, the budget priority given to commodity resource production activities, the lack of adequate reinvestment in reforestation and other non-commodity-resource values, and the lack of effective integration of research with resource management. Together these factors make it difficult to use innovation in forest management and grazing policy, have restricted the use of fire as a means to restore ecosystem structure and function, and have made it difficult to sustain a feedback loop based on intensive monitoring and evaluation between resource science and resource management.

5. How has the organizational structure of the Sequoia and Kings Canyon National Parks (SEKI) affected the interpretation of its mandate, the landscape, benefit flows, and conflict levels?

SEKI is also part of a strongly centralized and hierarchical organization, although in practice, SEKI represents a mid-range alternative to the less-centralized Mountain Home State Demonstration Forest and the strongly centralized Sequoia National Forest. Unlike either the national forest or the state forest, SEKI has a regular on-site research presence (although a separate unit from park administration) and hence potential to link research with resource management. Like the Sequoia National Forest, it must satisfy NEPA planning requirements. But in other respects, such as relative freedom from externally defined target output quotas, relative ability to fund its own research and direct its own research agenda, and a budget-setting process that is not based on commodity outputs but politically directed to individual park units, it has more local-level decision-making autonomy than the national forest. Consequently SEKI has relatively more authority and resources to improve the scientific basis and reduce the unanticipated consequences of its resource management plans. While this model of agency research dedicated to specific parks makes integration of research and resource management more likely, it also has limitations. Financial constraints and political and constituency pressures often challenge the ability of park resource managers to implement the management plans developed in consultation with park resource scientists. Under conditions of fiscal retrenchment, competition for funding often emerges between resource managers and research scientists. The creation of the National Biological Service (NBS) and subsequent transfer of all the research scientists from SEKI to the NBS is the most recent threat to SEKI's research capability.

Whereas on the Sequoia National Forest public support to fulfill its mission increased in the 1970s due to legislation requiring public involvement in resource planning, the early superintendents of SEKI had long depended on a measure of "visitor days" to legitimize the park's purpose and budget and to help justify its expansion. The low number of visitors

to the park during the first thirty years of its existence led to concerns among park administrators that, without adequate public support, it and the National Park Service might not survive. To generate more public support, radio and magazine publicity was encouraged, and a campfire program and guided nature walks for park visitors were initiated that have become the hallmark of the National Park Service's on-site interpretive program. Early superintendents of SEKI depended heavily on public support to fulfill its mission, obtain budget support, and help justify expansion. Both the National Park Service and the Forest Service were provided guidance by NEPA legislation to strengthen disclosure of planned activities and provide for public involvement in all significant management activities. The Sequoia National Forest received additional formal public involvement direction through the National Forest Management Act of 1976.

Consistent with its legislative mandate, and in contrast to the multiple-use mandates of Mountain Home State Demonstration Forest and Sequoia National Forest, SEKI has followed a preservationist and recreation strategy of land management in combination with efforts, initially, to encourage visitors and then, when their increasing numbers threatened the natural features the park was mandated to protect, to control and restrict visitor impacts. SEKI's current ecological landscape is a product of the historical institutionalization of total fire suppression; the park's preservation mandate, which limits commercial uses of the park's natural resources; the historically high visitation rates and concentration of visitors in some areas; and the commitment among park administrators to block proposed highways into the park's backcountry and across the Sierra crest to Owens Valley. The absence of commercial timber harvesting (significant numbers of trees have been removed to reduce hazards), mining, and grazing, combined with a commitment to minimize road construction, has preserved the integrity of larger landscape blocks than on the other agency jurisdictions in this study. Although reintroduction of fire has begun, fire suppression has interrupted ecological processes, transformed the forest structure, and halted the regeneration of some conifer species, notably giant sequoia.

6. How has the organizational structure of the Tule River Indian Reservation affected the interpretation of its mandate, the landscape, benefit flows, and conflict levels?

The objectives and policy that govern resource management on the Tule River Reservation are set by the nine elected members of the Tribal Council. In addition to the elected council, the traditional elders council also provides considerable leadership. Together the Tribal Council and elders council provide multiple informal avenues for conflict resolution and monitoring and sanctioning of individuals' resource management practices. The federal Bureau of Indian Affairs (BIA) has formal authority on the reservation but currently does not play an active role in natural resource management. The reservation's Natural Resource Department implements resource management programs with assistance provided by a resource management consulting firm.

The resource management philosophy of the reservation closely approximates Mountain Home State Demonstration Forest's multiple-use mandate, with the exception that the public owners live on the reservation. As on the demonstration forest, timber sales have historically been a primary source of locally generated revenue. Since the reservation assumed direct control of its natural resources from the BIA, its timber management program has sought to balance the economic value of timber with recreational and aesthetic values and the sociocultural benefits the forests provide the reservation's inhabitants. Unlike the federal and state institutions in this study, the reservation has a social review process that does not involve complex reporting and legal analysis.

In addition to timber harvesting, grazing and firewood cutting are important consumptive uses of the reservation's resource base. Firewood cutting is important for both local use and off-reservation sale. Rules restricting cutting areas are difficult to enforce. The resource management staff apparently feels that the social conflict that strict enforcement would generate does not warrant the slight improvement in resource management it would provide. Grazing on the reservation follows 1983 guidelines established to promote long-term range productivity and reduce some localized overgrazing problems. Stocking levels have decreased as some tribal members no longer graze stock and others have not increased their herd sizes. The physical impacts of relatively lax policies toward both firewood harvesting and grazing are visible to both the resource management staff and interested tribal members. Stronger responses could be developed and implemented if needed, but the staff clearly weighs this against the conflict among tribal members that would ensue.

The Tule River Indian Reservation's approach to resource management exemplifies the key tenets of a multiple-use management philosophy that balances commodity and noncommodity resource values. Timber harvest levels are planned to be compatible with noncommodity uses of the forest. In a manner analogous to the Mountain Home State Demonstration Forest, timber harvest receipts cross-subsidize other resource management activities and still produce a financial surplus. Most of the beneficiaries live on the parcel, unlike the beneficiaries of the other public institutions. Daily contact between stakeholders holding a range of goals and the resource managers who report to the Tribal Council provides numerous opportunities to discuss resource management and resolve conflicts without the formal reporting procedures used in most state and federal systems.

7. What are key organizational factors that influence how an institution interprets its mandate and with what ecological and social effects?

The case study descriptions suggest that the degree of organizational centralization, the extent of linkage between re-

source science and resource management, whether or not funding is tied to commodity resource outputs, the mechanisms for ensuring public accountability, and the degree of local-level planning and management autonomy shape how institutions interpret their mandates and the consequent effects on the landscape, benefit flows, and conflict levels. Two paired examples illustrate this: the Sequoia National Forest and the Mountain Home State Demonstration Forest, and Mountain Home State Demonstration Forest and the Tule River Indian Reservation. On paper, the mandates of the Sequoia National Forest and the Mountain Home State Demonstration Forest both emphasize "multiple use," but they give different weights to the importance of those multiple uses. Based only on knowledge of their respective mandates, we would expect the Sequoia National Forest to resemble a multiple-use forest and the state demonstration forest to be primarily oriented toward preserving giant sequoia and providing recreational opportunities. On the contrary, we have shown not only that both forests are managed as multiple-use forests but also that the ways in which conflicting patterns of resource use are reconciled, the integrity of the feedback loop between research and resource management, and the degree of controversy over resource management activities differ significantly. These differences can be accounted for by examining the differences in relative degree of centralization, constituency relations, and funding structure between the national forest and the state demonstration forest.

The Mountain Home State Demonstration Forest emphasizes timber production to cross-subsidize the administration and management of the rest of the forest. However, due to its decentralized organization and local planning autonomy, Mountain Home forest managers can practice intensive forest management in small patches of mixed conifer forest while simultaneously enhancing recreational opportunities and preserving giant sequoia groves in adjacent areas. Freedom from the need to maximize commodity output enables the forest managers to temper timber harvesting to reduce potential conflict with recreation use by using single-tree or small-group selection harvest methods and by decreasing the entry frequency by 50%. These same organizational and funding characteristics enable forest managers to experiment with, and monitor and evaluate, alternative timber management and fire regimes.

The Sequoia National Forest, by contrast, also manages for multiple use but through quite different organizational, planning, and funding structures. The strongly centralized organization of the forest administration, the tendency for funding to be linked with commodity outputs, and the lack of dedicated local research capacity limit the ability of the forest managers to develop innovative timber management plans. More flexible funding arrangements that do not prioritize commodity over noncommodity resource management, a more complete feedback loop between research and resource management, and a more vigorous set of outreach and interpretive programs may have resulted in less-controversial resource management plans.

The Mountain Home State Demonstration Forest and the Tule River Indian Reservation illustrate an example in which the high constituency accountability of the latter and the mandate of the former produced roughly comparable landscape outcomes. Both these institutions follow intensive resource management programs that nevertheless are able to balance commodity and noncommodity resource values in ways that satisfy the diverse needs of the public(s) to whom they are accountable. The Tule River Indian Reservation is not mandated to follow any specific resource management approach. Its culturally attuned multiple-use management regime developed because of the high levels of accountability reinforced through a number of political and cultural channels. The Mountain Home State Demonstration Forest also provides a mix of commodity and noncommodity resources, but not because of formal public accountability procedures. In contrast to the complex public input procedures used on both the national park and the national forest, public input for these two smaller parcels is more informal and less structured. Nevertheless, both the Tule River Indian Reservation and the demonstration forest have a strong record of being responsive to local concerns.

8. What factors influence an institution's effectiveness under increasingly complex and contested conditions?

The case study descriptions suggest that the ability to maintain institutional legitimacy and public trust, the ability to obtain and integrate local research with resource management, and interagency coordination influence an institution's effectiveness under conditions of porous boundaries and complex social and political environments.

Maintaining institutional legitimacy and the public's trust is increasingly difficult as social and political environments become increasingly complex and the tensions inherent in satisfying diverse and sometimes conflicting values grow stronger. Formal and informal procedures for public involvement can together preserve institutional legitimacy and contain conflict within acceptable bounds. A public agency is more likely to retain its institutional legitimacy and the trust of the public owners of the resources it manages by following a proactive strategy of public outreach, on- and off-site interpretative programs, and extension work that involves all of the various concerned interest groups. Accomplishing this probably requires a minimal degree of local-level autonomy, a widening of the envelope of acceptable planning outcomes in the interests of fostering substantive public involvement, leadership support and organizational incentives for personnel to invest time and energy in outreach efforts, and a nondefensive attitude that allows errors to be acknowledged and transformed into learning opportunities.

On-site research capacity, either "in-house" as at Sequoia and Kings Canyon National Parks, or contracted out, as at the Mountain Home State Demonstration Forest, provided

the monitoring and evaluation capacity necessary for minimizing the unanticipated effects of management plans and, when combined with local-level planning autonomy, an information base for developing micro-scale management plans. A "hybrid" research organization that combines elements of the separate Forest Service Research branch and the localized Park Service research program might provide local autonomy for effective feedback between research and resource management while simultaneously providing organizational resources and insulation from short-term administrative imperatives necessary for sustained research. Although independence is important, effective integration of research with resource management will occur only when research is organized at the local level, either through "in-house" administrative studies or through cooperative studies involving university researchers or scientists in other state and federal natural resource agencies.

Interagency coordination emerges when the benefits outweigh the costs of coordination. Cooperative interagency research capitalizes on the comparative advantages of different resource management agencies as well as the expertise of university researchers. Interagency associations such as the Giant Sequoia Ecology Cooperative can function as clearinghouses for sharing recent research and provide local-level arenas for resolving potential conflicts among agencies and between them and local communities and local governments. All forms of interagency coordination help bring policy and managerial coherence to ecosystems driven by jurisdictional boundaries.

The organizational structure of public resource management institutions affects the social and ecological outcomes they create as well as their ability to manage complex environments and porous boundaries. This comparative case study has identified potential organizational policy levers that influence the ability of public institutions to handle complexity and porosity. The range of levers includes shifts in the funding and organization of research to create new research relationships, relaxing of links between commodity outputs and budget levels, local-level flexibility, means and incentives necessary for maintaining institutional accountability and legitimacy, and formal and informal modes of interagency coordination at all levels. Policies that operate in these nonlegislative arenas are often process- rather than target-oriented; instead of legislating outcomes, they attempt to create institutional mechanisms for resolving conflict that incorporate scientific research and maintain institutional accountability.

CONCLUDING NOTES ON THE CASE STUDIES

It is self-evident to conclude that institutions must cooperate to manage ecosystems. This chapter illustrates different forms of cooperation with an understanding that most progress toward stewardship and sustainability involves a good deal of conflict. There are, in the Sierra, different scales of interest. Ecosystems like Lake Tahoe, the Mammoth-June region, and the giant sequoia region have a national and international constituency, yet the commitment of local institutions is required before progress toward sustainability can be made.

There is much to be said for local control over management, as illustrated by the efficiency of Mountain Home State Demonstration Forest. But at Lake Tahoe, Mammoth-June, and the giant sequoia region, the national interest expressed through federal agencies in those places has been critical to a long-term and comprehensive approach to planning and management. In Lake Tahoe and the giant sequoia region, state institutions have shown leadership and intelligent restoration and ecosystem management. These case studies have confirmed the importance of balance among local, state, and national interests.

The chapter has emphasized institutional arrangements. Yet the SNEP assessment team fully recognizes that where there are successes, there are committed individuals who have remained in an area long enough to develop sophisticated knowledge of the ecosystem and credibility throughout the community of institutions.


Back to CD-ROM Table of Contents