1998

A Framework for Understanding Social Science Contributions to Ecosystem Management

Joanna Endter-Wada
Utah State University

Dale Blahna
US Forest Services

Richard S. Krannich
Utah State University

Mark W. Brunson
Utah State University

Recommended Citation

Endter-Wada, J., D. Blahna, R. Krannich and M. Brunson. 1998. A framework for understanding social science contributions to ecosystem management. Ecological Applications 8(3):891-904.

Ecological Applications, 8(3), 1998, pp. 891–904

A FRAMEWORK FOR UNDERSTANDING SOCIAL SCIENCE CONTRIBUTIONS TO ECOSYSTEM MANAGEMENT

Joanna Endter-Wada,[1,2] Dale Blahna,[1] Richard Krannich,[1,2] and Mark Brunson[1]

[1]*Department of Forest Resources, Utah State University, Logan, Utah 84322-5215 USA*
[2]*Department of Sociology, Social Work, and Anthropology, Utah State University, Logan, Utah 84322-0730 USA*

Abstract. We propose a framework for understanding the role that the social sciences should play in ecosystem management. Most of the ecosystem management literature assumes that scientific understanding of ecosystems is solely the purview of natural scientists. While the evolving principles of ecosystem management recognize that people play an important role, social considerations are usually limited to political and decision-making processes and to development of environmental education. This view is incomplete. The social science aspect of ecosystem management has two distinct components: one that concerns greater public involvement in the ecosystem management decision-making process, and one that concerns integrating social considerations into the science of understanding ecosystems. Ecosystem management decisions based primarily on biophysical factors can polarize people, making policy processes more divisive than usual. Ecological data must be supplemented with scientific analysis of the key social factors relevant to a particular ecosystem. Objective social science analysis should be included on an equal basis with ecological science inquiry and with data from public involvement. A conceptual framework is presented to communicate to ecological scientists the potential array of social science contributions to ecosystem management.

Key words: adaptive management; ecosystem management; environmental policy; National Environmental Policy Act; public involvement; social impact assessment; social science.

Introduction

The proliferating literature on ecosystem management contains many debates over the philosophical foundation, definition, principles, techniques, and implementation of what is being acclaimed as a fundamentally new approach to natural resource management. This paper contributes to these debates by discussing the role of the social sciences in ecosystem management, an aspect that we believe is often misunderstood in the current process of formulating an ecosystem management approach to natural resource management in the United States. Scholars in various social science disciplines have devised approaches to studying the relationships between human societies and their environmental contexts. Because these disciplinary approaches can inform the ecosystem management process, we propose a broad conceptual framework that, while not definitive, offers ecologists and natural resource managers a way to think about how social science data and analyses might assist in understanding ecosystem management problems. This paper is not intended to provide specifics on the principles and methods for applying social science inquiry, but rather is a translation device to provide ecologists with a better understanding of distinct domains of social science contributions.

Manuscript received 18 April 1997; revised 29 September 1997; accepted 6 October 1997; final version received 4 November 1997.

Ecosystem management is emerging as the dominant paradigm for managing many public lands in the United States (FEMAT 1993, Bureau of Land Management 1994, U.S. Forest Service 1994, Interagency Ecosystem Management Task Force 1995). Its meaning has evolved to include several common themes or principles. Ecosystem management is usually defined to mean focusing on ecological systems that may cross administrative and political boundaries, incorporating a ''systems'' perspective sensitive to issues of scale, and managing for ecological integrity (e.g., conserving species and population diversity, dynamic processes, and representative systems). The evolving definition also includes recognition of the need to manage for the sustainability of human as well as ecological communities, to practice adaptive management, and to encourage broad-based involvement and collaboration in implementing ecosystem management (Salwasser 1991, 1992, LeMaster and Parker 1993, Slocombe 1993, Covington and DeBano 1994, Grumbine 1994, Jensen and Bourgeron 1994, Moote et al. 1994, Everett and Baumgartner 1995, Wagner 1995).

Much of the current debate about ecosystem management is over whether it is possible to achieve the goal of balancing social, economic, and ecological considerations. Those who do not believe this is possible often frame their arguments in terms of an abstract philosophical dichotomy between biocentrism (or ecocentrism) and anthropocentrism (or humanism). The biocentrist position considers the primary goal of ecosystem management to be maintaining ecological integrity, and generally assumes that human influences are detrimental to ecological systems (Norton 1991, Soule 1991, Ludwig 1993, Bell 1994, Noss and Cooperrider 1994, Stanley 1995). The anthropocentrist position emphasizes the importance of human resource uses, and often assumes that ecological systems are resilient to such use (American Forest and Paper Association 1995, Wiant 1995). Disagreement over whether ecological or social factors should have priority is at the center of debates over the likelihood of achieving ecosystem management (Salwasser 1991, 1992, Frissell et al. 1992, Lawrence and Murphy 1992).

Since there is considerable contention over what is meant by the integration of human dimensions into ecosystem management, it is not surprising that this aspect of the evolving ecosystem management paradigm is most in need of clarification. While the evolving definitions and principles often include a recognition that people are a part of ecosystems and need to be included in decision making (e.g., Human Dimension Study Group 1994), in most applications social considerations are included only as part of the decision-making and political processes involved in initiating and implementing ecosystem management. In this respect, social scientists often are perceived to be the ones who will help resource agencies manage conflicts and avoid litigation, improve public participation processes, and provide environmental education.

While ecologists recognize that the social–political component of ecosystem management is important, the social scientific contributions to ecosystem management are often ignored or misunderstood. For example, in one of the most widely cited papers on the topic, Grumbine (1994) argues that ecological integrity must be the primary concern of ecosystem management, and that it is not possible to balance ecological, economic, and social concerns as resource agencies are trying to define the paradigm. In discussing the role of scientists in ecosystem management, he identifies only physical and biological science needs; issues related to ''regional economics'' and ''population growth and resource consumption'' are viewed as the purview of policy makers and ''fostering cooperation and opening up the decision making process'' as a job for resource managers (Grumbine 1994:32–33). More recently, Grumbine still misrepresents the role of social science through a false dichotomy between ''science'' and ''social data.'' He points out an omission in his earlier article, where he says he ''focused on scientific data collection, but this is too narrow . . . [m]anagers also need social data to do their jobs'' and that ''studies confirm that non-biological data are often more important than scientific information in solving management problems'' (Grumbine 1997:44). Similar assumptions that ecosystem management science will be handled by ecologists, with social considerations relegated to managerial or political domains, have been made by other natural scientists (e.g., Noss and Cooperrider 1994, Wood 1994, Wagner 1995). These authors, while recognizing the political realities of ecosystem management, fail to note the scientific contributions that can be made by political scientists, sociologists, anthropologists, economists, and other social scientists who study human populations.

The unstated implication of such perceptions is that scientific inquiry related to ecosystem management is the realm of natural scientists, and that the social scientists' realm is implementing or perhaps studying (although this is rarely mentioned) the political processes related to ecosystem management. At best, this implies that when there is a range of management options that could meet ecological goals, natural scientists should be aware of (1) the diversity of public opinions that may exist regarding these options, and (2) the need to weigh these opinions in the decision-making process. At worst, it implies that people are political obstacles to implementing what the natural scientists believe is necessary to meet ecological goals, and that the role of social science is to understand how to ''educate'' people so they become more supportive of those goals (e.g., Noss and Cooperrider 1994:328).

In order to help clarify the role of the social sciences in ecosystem management, we have developed a framework (Fig. 1) that we believe can illustrate the range and variation of the contributions the social sciences can make to ecosystem management. Its central premise is that there are two distinct social components in the evolving definition of ecosystem management. One component concerns greater public involvement in decision-making and in formulating policies and strategies for ecosystem management (the left side of Fig. 1). The other component concerns social analysis, or integrating social considerations into the science of understanding ecosystems and their management by humans (the right side of Fig. 1). The traditional view of the distinction between these components is based upon the obvious process elements of the public involvement component and the substantive data elements of the scientific component (e.g., Slocombe 1993:618). However, we argue that each component actually has both process and data aspects. Each component can involve people in decision-making processes regarding ecosystems and also produce substantive social science data about humans in ecosystems. Only by acknowledging and incorporating all four aspects into ecosystem management decision-making can we achieve a level of social knowledge sufficient to incorporate people into ecosystem management.

Humans as Components of Ecosystems

Reports and position statements from both resource agencies and university scientists invariably include ''humans as an integral part of ecosystems'' as a general principle of ecosystem management (ENN Staff 1993:2, Iverson 1994, Grumbine 1994, Christensen et

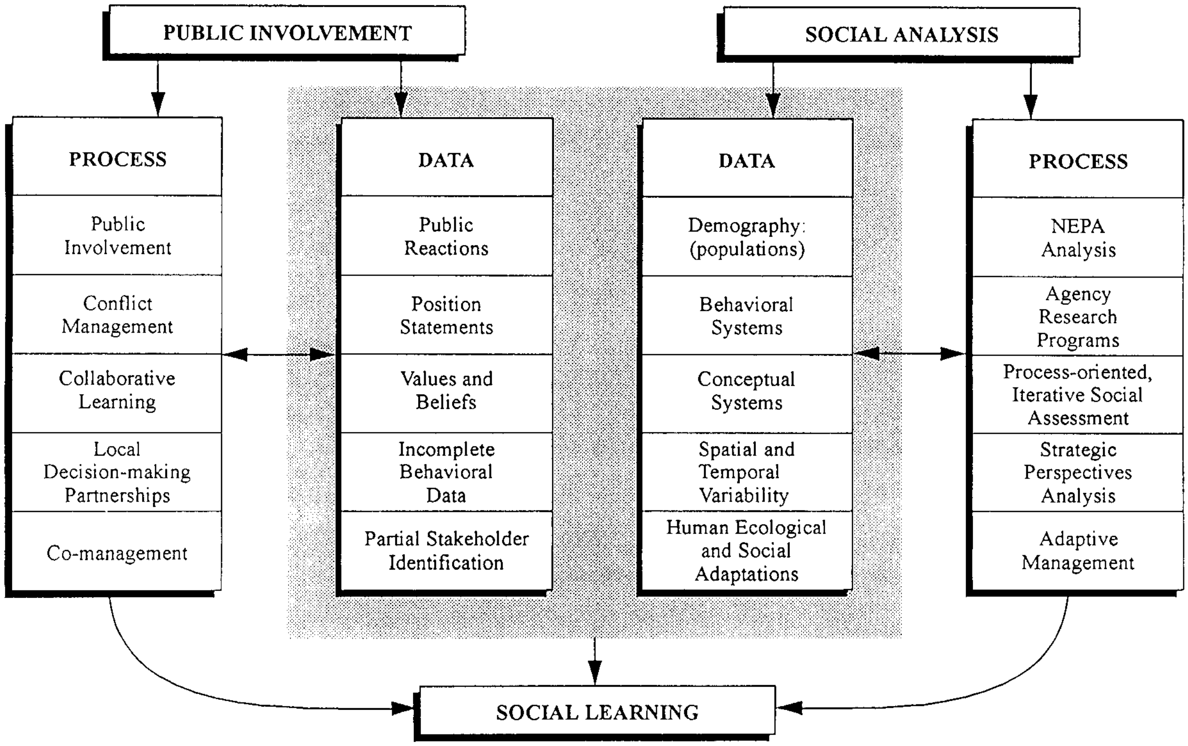

FIG. 1. A framework for social science contributions to ecosystem management.

al. 1996, Harwell et al. 1996, Mangel et al. 1996). Specifying what the social scientists' role should be and how it might best be integrated into the process of developing an ecosystem management approach, however, has yet to be adequately explicated or fully implemented.

Some authors, especially in the academic community, argue that understanding the biophysical nature of ecosystems and sustaining ecological integrity is the primary goal of ecosystem management (Grumbine 1994, Christensen et al. 1996). ''Humans as part of ecosystems'' enters into this image of ecosystem management in two ways. First, there is a need to understand how humans impact natural systems (i.e., how they act to prevent an ecosystem from being in its ''natural'' condition). The inherent assumption of this perspective is that humans are the antithesis of ''nature'' and human activity patterns and biological impacts need to be studied. An example of this analysis approach is the desert tortoise habitat rehabilitation plan prepared by the U.S. Fish and Wildlife Service (1994).

The second way that humans figure into ecosystem management based on the ecological integrity model is through the recognition that ecosystem management should incorporate ''human values'' in decision making (Grumbine 1994), which is part of the political aspect of ecosystem management, as discussed above. Thus, the role of social science per se is not to study humans as interacting elements of ecosystems (having both positive and negative effects, with ecosystems providing some essential commodities or experiences for humans) but simply as deterrents to natural processes. Instead of systematically analyzing the interaction of humans in ecosystems, the social component enters the decision process haphazardly (i.e., unscientifically) in the political arena after the biophysical or ''scientific'' data are collected.

For resource management agencies, on the other hand, especially the Forest Service and Bureau of Land Management, the ''humans are an integral part of nature'' principle is more than just rhetoric. Despite criticism from some in the ecological community, agency position statements continue to emphasize that ecosystem management means balancing both social and ecological goals (Environmental News Network Staff 1993, Iverson 1994, U.S. Forest Service 1994, Carr 1995), and recent task force reports have provided some preliminary scientific and process guidance for implementing the social component of ecosystem management (Guldin and Henderson 1993, Super et al. 1993, National Task Force on the Human Dimensions of Ecosystems Management 1994 (review draft); Interagency Ecosystem Management Task Force 1995). For example, the Forest Service's Human Dimensions Task Force has identified several hundred types of social analysis measures and is developing a process model for integrating social and ecological factors in ecosystem management.

In recent years, several major ecosystem assessments conducted by federal land management agencies have exhibited increased attention to social dimensions. For example, an evaluation of community capacity to respond to changes in timber harvest was incorporated into the analyses presented in the FEMAT (Forest Ecosystem Management Assessment Team) Report (FEMAT Report 1993). The Interior Columbia Basin Ecosystem Management Project conducted broader ranging and more in-depth analyses of local economic and demographic trends across the region, along with a relatively ambitious assessment of adaptive capacity and resiliency in 198 local communities (Harris et al. 1996). Similarly, the social assessment effort conducted as part of the Sierra Nevada Ecosystem Project included a detailed investigation of several dimensions of community well-being and the relationships between well-being and various policy scenarios across 180 localized areas (Doak and Kusel 1996). Such efforts indicate meaningful progress toward improved consideration of social factors in ecosystem management. At the same time, there remain unresolved questions about the specific social dimensions that need to be addressed, the appropriate scales of analysis, and the ways in which such input might be more effectively linked to biophysical analyses.

Public Involvement in Planning and Policy Making

Most of the emphasis on integrating humans into ecosystem management has focused on this first component: involving people in decision-making processes. Land management agencies are being compelled to work more effectively with diverse constituents and other governmental entities in their attempts to manage ecological units that usually cross land ownership and jurisdictional boundaries (e.g., Greater Yellowstone Coordinating Committee 1990, Southern Appalachian Man and Biosphere Cooperative 1996). In addition, federal resource managers have sought to involve people in decision making in response to legal and administrative mandates directing them to do so, increased conflict and litigation over managing public lands, and growing public distrust of resource managers and scientists (Kennedy and Quigley 1993, Shepard 1993, Daniels et al. 1994, Endter-Wada and Lilieholm 1995). These factors have contributed to widespread consensus that forging partnerships with people and creating more meaningful opportunities for public participation should be part of the ecosystem management paradigm (Daniels and Walker 1995, Thomas 1995, Walker and Daniels 1996).

Public involvement processes

The search for more effective means to deal with people and politics has been the main impetus for resource agencies to incorporate social science into resource management. Resource managers have turned to social scientists for practical and applied tools that will help them address the needs and concerns of increasingly diverse and contentious constituencies and be more effective in their attempts to educate and influence policy makers and public opinion on ecological issues. While social scientists are sometimes asked to help facilitate agency/public interactions, their main contributions lie in applying their understanding of human behavior to an analysis of conflicts and processes for managing them (see Fig. 1).

Some social scientists focus their research and analysis on broader processes of group and societal decision-making; i.e., the objects of their science are these processes. Their work generally analyzes the structure and dynamics of various public involvement processes, the conditions under which these processes work best, their suitability for addressing different types of problems, their effectiveness in facilitating public involvement, and their success in improving situations or attaining desired outcomes (e.g. Heberlein 1976, Howell 1987, Blahna and Yonts-Shepard 1989, 1990). Other social scientists have borrowed heavily from conflict negotiation and mediation experiences outside natural resources (e.g., labor disputes, divorce settlements) and applied these techniques to understanding and managing those conflicts (e.g., Bingham 1986, Amy 1987, Crowfoot and Wondolleck 1990, Yaffee 1994).

While generalizable principles about public involvement processes have emerged from these studies, application of this knowledge to natural resource management is not systematic. Using this knowledge to increase public involvement in ecosystem management entails difficulties due to the history of land management politics, unsettled questions regarding the Federal Advisory Committee Act (FACA), and the special challenges of ecosystem management (Daniels et al. 1994). However, its application is leading to some innovative approaches to participatory decision-making that attempt to involve people in decision-making earlier and on a more continual basis, and we hope, before conflicts develop (left column of Fig. 1). These approaches include collaborative learning (Daniels and Walker 1995), local decision-making partnerships (Kemmis 1990, Preister 1994), and, in the international arena and in relationships with sovereign native groups, comanagement of resources and even protected areas (e.g., Berkes et al. 1991, West and Brechin 1991, DeLacy 1994).

Public involvement data

As Fig. 1 suggests, public involvement processes yield data as well as political efficacy. Public participation in standard agency planning procedures (e.g., advisory committees prior to recent Federal Advisory Committee Act restrictions, legally mandated public hearings) has been the traditional way resource agencies have obtained information about different constituencies. Most often public involvement data reflect the reactions of selected constituents and self-identified stakeholders to particular agency actions, proposals, or management practices. In its least useful forms, public involvement provides little more than an indication of public reactions and position statements, i.e., whether those who participate in a particular process support or oppose specific management activities or proposals. However, processes that facilitate input extending beyond the simple expression of support/opposition can yield important insights into the ways in which participants relate to certain resources or resource areas, as well as their more general values, beliefs, and preferences regarding resource use and management. As such, public involvement data may help to identify the extent to which, and more importantly the reasons why, various management strategies are likely to be considered either acceptable or unacceptable, at least among those individuals and groups who become engaged in the public involvement process.

While traditional public involvement processes can provide important and substantive data about the role of humans in ecosystems, these data are usually incomplete due to the limitations of the methods used to elicit data in these contexts, and because many stakeholders are not represented in these forums (Blahna and Yonts-Shepard 1989, Office of Technology Assessment 1992). For example, public involvement processes are unlikely to provide data that can be used to assess the full range of behaviors, cultural traditions, life ways, or social values and meanings that link human populations materially as well as symbolically to natural resources, that influence those populations' uses of resources, and that determine their levels of vulnerability to changing resource conditions. Also, there is a tendency for over-representation of social groups and constituencies that are consciously aware that they have a stake in the outcome of resource management decisions and that possess the social, political, and/or financial capital needed to engage as active participants in such processes (Heberlein 1976). Furthermore, even preliminary ecosystem management decisions that are based solely or primarily on biophysical factors may polarize people, making the decision-making processes divisive and causing data derived from public involvement to be more biased and less representative than usual.

In short, public involvement data generally fail to either measure the full spectrum of relevant linkages between the social and biophysical realms or to address the variability in those linkages across the full spectrum of relevant human communities and groups. Data derived from public involvement processes are generally suspect in terms of representativeness, and as such do not support inference to known communities or publics. Often key social conditions and trends that need to be taken into account in evaluating social/ecosystem dynamics are not addressed at all in the course of public involvement processes. Also, such data seldom fare well with respect to the standards of validity and measurement reliability to which more traditional forms of social science inquiry are held within the scientific community and in court.

However, public involvement processes can provide an important context for establishing improved understanding of key social values, uses, and concerns that bear upon changes in ecosystem conditions and ecosystem management options. If properly designed and implemented, they can also provide an important mechanism for encouraging a more collaborative public role in the definition of problems and the delineation of paths toward improvement. Moreover, from a practical standpoint, data derived from public involvement can provide an extremely useful, albeit incomplete, ''coarse filter'' for identifying and characterizing many of the communities and social groups that are linked in various ways to a particular ecosystem, and some of the more important dimensions of those linkages. The preliminary understandings derived from such information can provide important guidance in designing and implementing more focused social science data collection efforts that will support rigorous, in-depth, and scientifically defensible analyses of the key social factors that are relevant to a particular ecosystem.

Incorporating Social Analysis into Ecosystem Science

Less emphasis has been placed on the second component of our framework, that of incorporating humans into the science of understanding ecosystems (the social analysis portion of Fig. 1). Humans have been neglected as components of ecosystem science for reasons related to the social context and the process by which ecosystem science has developed. One reason is that this science is based on Enlightenment religious and intellectual traditions that viewed humans as separate from nature. This view tends to be reinforced when ecosystem concepts are applied to public lands in North America, where now there are relatively few resident people, and human influences are comparatively more controlled. The need to bound ecological science for analytic manageability is another reason humans have been neglected in ecosystem science. And finally, the scientific staff of federal resource agencies has been and continues to be heavily weighted toward the biological sciences, with social sciences being poorly represented (Wenner 1987, Kennedy 1991).

In addition to this broader social context in which an ecosystem management approach has evolved, there have been obstacles within the scientific professions to integrating biophysical and social sciences. The first obstacle has to do with differences between the epistemologies and paradigms in which natural and social scientists train and work. Most simply, natural scientists view humans as intruders in ecosystems and focus on the need to preserve or conserve natural resources (e.g., Noss and Cooperrider 1994), while social scientists tend to view ecosystems as providers of goods and services to humans and focus more on the uses and values humans associate with resources (Catton and Dunlap 1980). In addition to this basic difference in perspective, other obstacles to scientific integration include: less frequent professional interactions between social and natural scientists; communication barriers posed by discipline-specific technical language; incompatibility of natural and social scientific data over geographic scales, time scales, and units of measurement; and incentive structures that reward scientists for specialization within their disciplines and discourage interdisciplinary collaboration (Ocean Studies Board and National Research Council 1995:44–45, Mangel et al. 1996:348).

Other reasons that less attention has been given to incorporating humans into the science of understanding ecosystems has to do with the fact that discussions about ecosystem management traditionally have taken place among resource managers, scientists, and professionals trained in the natural sciences. Their conceptualizations of ecosystems and of research agendas were defined in ecological terms, with little integration of human components other than as constraints or stresses on ecological processes (e.g., Burgess 1993, Kaufmann et al. 1994, Noss and Cooperrider 1994, Wood 1994). Alarmed that many ecosystems faced risks from population growth and human impacts, they proposed accelerating the study of ''pristine'' natural systems as a preliminary step to determining the impacts of human actions on those systems and identifying management alternatives aimed at minimizing those impacts. The foundation and technical aspects of much of good resource management are still perceived to be good ecological science, with management objectives driven by the need to protect biological diversity and/or replicate pre-European ecological conditions. But while some ecologists still limit their acknowledgement of the importance of humans to the effect that pre-European residents had on their natural environments (Owen-Smith 1989, Wagner and Kay 1993, Young et al. 1995, Mangel et al. 1996), there now seems to be the emergence of a comprehensive call for incorporating human uses and interactions as a focus of ecosystem analyses.

As noted above, there have been several examples of ecoregional, interagency ecosystem management projects incorporating social factors, such as the FEMAT Report (1993), the South Florida Everglades Restoration Project (Harwell et al. 1996), the Interior Columbia Basin Ecosystem Management Project (Haynes et al. 1996, Quigley et al. 1996, U.S. Forest Service 1996), the Southern Appalachian Assessment (Southern Appalachian Man and Biosphere Cooperative 1996), and the Sierra Nevada Ecosystem Project (Doak and Kusel 1996). While these ecosystem pilot projects incorporated social data and had similar goals, each one took a different approach to the amount and type of social science data collected. For example, despite the similar scope and broad goals of these projects, each used a completely different unit of analysis for describing existing social conditions in the ecoregion. For the Sierra Nevada project, social scientists identified 180 ''community aggregates,'' which were combinations of census block groups that roughly corresponded to communities or combinations of small towns that were linked socially and economically (Doak and Kusel 1996). The aggregates were based on a sophisticated quantitative analysis of five indices developed from census and spatial variables in six multicounty ''regions'' of the Sierra Nevada. The ICRB project simply used counties of the Columbia Basin as the unit of social analysis (Quigley et al. 1996), and for the Everglades, scientists treated all of South Florida as one large social group (Harwell et al. 1996).

The dependent variables used in these ecoregional projects were equally diverse. The Sierra Nevada project used population, community capacity, socioeconomic status, tenure (home ownership), poverty, education, employment, and families receiving public assistance to describe the six regions, and socioeconomic status and community capacity index scores to describe the community aggregates. The descriptive variables used to describe the Interior Columbia counties were social and economic resiliency, population growth, sector of employment, and timber harvest and forage from federal lands.

The diversity in social science approaches is the result of the size and complexity of project objectives, availability of expertise and funding, and lack of existing standards for conducting social science at various scales of analysis. This is not to say that these social assessments have not been valuable additions to the ecoregional projects. The Everglades project provided a more thorough analysis of the integration of ecological and human systems, and recommended different levels of participation of public and private landowners in managing for ecological and societal sustainability in the Everglades ecoregion (Harwell et al. 1996). But the project implications derived from these analyses are necessarily broad planning objectives. Large amounts of data are collected, focusing on general assessments of existing conditions and needs, with little attention to addressing project or site-specific issues. While this general guidance is a necessary first step, the vast majority of ecosystem management decisions will be made at a smaller scale—the landscape, watershed, or agency unit levels—and ecoregional pilot projects can only provide the broadest level of guidance.

There are also numerous small-scale ecosystem management projects, which tend to be written up primarily as individual case studies, with little generalizable information (e.g., Super et al. 1993, Yaffee et al. 1996). For example, a recent review of 105 site-specific case studies by Yaffee et al. (1996) resulted in excellent summaries of the types and sizes of projects, the nature of agency participation and existing land uses in those projects, and the obstacles and opportunities for moving the projects forward. This review also contains a summary of the ''anthropogenic stresses on project areas'' (Yaffee et al. 1996: 69–71). However, this reflects the use of social science data to identify the ecological impacts of humans, and only to a lesser degree their benefits, needs, and preferences. This review illustrated the need for public participation and local community support for ecosystem management projects, but no implications were drawn for the integration of social science in the decision frameworks.

Thus, there is widespread recognition of the need for systematic social science information in ecosystem management, but most emphasis is placed on political process implications. The ecoregional pilot projects provide little guidance for on-the-ground planning beyond recommending general goals and objectives for management directions and some possible categories of social variables. At the landscape and watershed levels of analysis, issues are more specific, data types and sources will differ, and relevant social analysis, units of analysis, and public involvement methods will necessarily differ from ecoregional pilot programs. In short, site-specific projects may build on findings from broader scale pilots, but must collect unique sets of social scientific data.

Social scientific data

The scientific separation that has been maintained between humans and ecological systems has been philosophical, analytic, and professional. It has largely ignored empirical reality. Humans have impacted ecosystems over time through a range of interactions, which include use, habitation, and management (McDonnell and Pickett 1993). Growing recognition of the pervasiveness of human-induced ecological change has led to reassessment and revision of the environmental history of certain areas, with profound implications for current management policies (Wagner and Kay 1993, Wagner 1996). Some European ecologists label the focus of their ecological studies ''cultural landscapes'' and talk about ''a gradient of human impact'' because of the pervasiveness of human ecological influences (McDonnell and Pickett 1993).

Humans are intimately connected with and influence ecological systems, and there is growing recognition that understanding those connections is the key to developing an adaptive and effective ecosystem management approach (Moran 1990, Bonnicksen 1991, McDonnell and Pickett 1993, Slocombe 1993, Gunderson et al. 1995, Harwell et al. 1996, Mangel et al. 1996). The contributions of social science to ecosystem management can range from macro-level analyses of broad social, cultural, political, and economic values, behaviors, and trends to micro-level analyses of individual and group attitudes, values, and behaviors (Fig. 1). For example, demographic analyses and projections can provide a basis for understanding the dynamics of population change and distribution for local areas, regions, and the nation. Because human influences on ecosystems are likely to vary depending on the size and composition of the populations that live in and/or make use of various places and resources, knowledge of historical and current population trends is one key component of the effort to establish and understand linkages between human and biophysical components of ecosystems.

Simple understanding of demographic composition and trends is insufficient for understanding complex behavioral systems and their linkages to resource conditions and dynamics. For example, analyses based on the principles of social or human ecology are useful in documenting linkages between the population dynamics of human communities and the economic structures that sustain those communities (Frisbie and Poston 1978, Burch and DeLuca 1984, Moran 1990). Such analyses can provide important insights into the relationships between resource-based economic activities; trends and prospects for community growth, stability, or decline; and associated prospects for the social well-being of people living in human communities that are linked to specific ecosystems (Field and Burch 1988, Wilkinson 1991). The ability to assess interrelationships between resource conditions and trends, economic activity, population dynamics, community stability, and social well-being is crucial to anticipating what may be ''coming down the pike'' with respect to future resource uses and demands (US Forest Service 1995).

Scientific analyses of the social organizational structures of human communities provide another key set of insights into the linkages between the biophysical and social components of ecosystems. Issues of spatial and temporal variability are as important for understanding social aspects of ecosystems as for understanding the biophysical aspects. Resource uses, needs, and values are differentially distributed across local territorial communities, broader-based ''communities of interest,'' and the vast array of social groups that comprise these larger units of social organization. Within communities, understanding power differentials and social and economic equity issues in relationship to resource use and access is another area for formal social analysis (Jorgensen 1972, 1978, 1990, Endter 1987, West 1994). Implementing ecosystem management may result in social effects that are distributed unevenly across different interests and user groups. Public involvement activities will seldom provide a representative sampling of these various interests (recent work in the Southern Appalachians is a notable exception). Active collaboration and group process activities are influenced by different power and domination dynamics that must be considered in ecosystem management decision making.

The ability to characterize and understand linkages between resource conditions and trends and particular social groups and to determine how those linkages vary across groups and communities is central to social assessment efforts, whether those efforts involve project-level analyses or analyses oriented to the larger geographic and temporal scales that are inherent to ecosystem-based management. Such analyses in turn provide the foundation for evaluating the relative ''resiliency,'' ''adaptability,'' or ''vulnerability'' of human communities and groups to anticipated shifts in ecosystem conditions and management orientations (FEMAT Report 1993, Krannich et al. 1994, Jorgensen 1995, Harris et al. 1996, Endter-Wada and Levine 1996).

Social scientists can also provide much-needed insight into the nature of human conceptual systems (e.g., social beliefs and values) regarding resource uses, conditions, and management approaches. The widespread and entrenched use of economic analysis in agency decision-making has been the main approach to measuring values, behaviors, and ecosystem interactions. Numerous authors have asserted that a more comprehensive understanding of human values is of central importance in the definition and implementation of ecosystem management (e.g., Salwasser 1991, 1992, Grumbine 1994, Lackey 1996, Wagner 1996). However, rigorous and systematic data collection and analysis will be required if we are to move beyond the rhetoric of simply acknowledging the importance of human values (and of measuring them solely in economic terms) to actually incorporating a range of value considerations into management practices and decision-making. Human values are highly variable across cultures, segments of societies, and stakeholder groups, and thus need to be analyzed empirically and across social science disciplines.

Anthropological and sociological theories and research can provide important insights into human conceptual systems regarding ecosystems. Social values and meanings about resources and landscapes have been traced to their roots in cultural traditions and individual or group experiences (e.g., Jorgensen 1984, Endter 1987, Endter-Wada et al. 1992, Greider and Garkovich 1994). Research examining how different social groups and communities interpret and form attachments to particular places or natural features can provide invaluable information about how and why certain resource uses occur and persist, as well as how shifts in resource conditions can influence human adaptation and response (Endter 1987, Brandenburg and Carroll 1995, Edelstein and Kleese 1995). Other researchers, drawing from ideas about evolution, psychophysiology, aesthetics, social psychology, and forest ecology, have developed landscape perception theories that can be used to assess scenic quality and predict changes associated with management activities (e.g., Brown and Daniel 1986, Kaplan and Kaplan 1989).

Some of these social-scientific approaches have already been applied to specific research topics relating to ecosystem management. For example, Gobster (1995) applied landscape perception theories to ecosystem management issues, producing recommendations about ecologically sustainable approaches to preserving forest scenic quality. Brunson (1993) applied concepts drawn from social and environmental psychology to evaluate what is meant by the ''social acceptability'' of resource conditions and management practices associated with ecosystem management. Researchers also have begun to study public attitudes toward ecosystem management principles and strategies (e.g., Reading et al. 1994, Brunson et al. 1996, Shindler et al. 1996).

Social scientific processes

The National Environmental Policy Act of 1969 (NEPA) required federal agencies to collect data that were representative of interested and affected publics, thereby providing the first legal requirement to conduct social analysis in resource planning. While agency-specific legislation has verified this need (e.g., the National Forest Management Act of 1976), the regulatory directives for implementing the law fail to provide clear guidance about when and how social analysis needs to be applied. Although some agencies and other organizations have developed more detailed guidelines for conducting social assessments (e.g., Branch et al. 1984, Interorganizational Committee 1993), there is little evidence that resource management agencies have developed either the will or the ability to collect social science data that are clearly relevant to decision-making needs (Freudenburg and Keating 1985, Blahna and Yonts-Shepard 1989, Krannich et al. 1994). Instead, agency social analyses seem in most instances to be driven by a need to adhere to NEPA process requirements and often suffer from the lack of discipline-appropriate scientific expertise among agency staff.

These criticisms, as well as the need to conduct analyses over larger geographic areas (Krannich et al. 1994) and longer time frames (Burdge 1987, Geisler 1993) and to account for increased scientific uncertainty and complexity in both social and ecological systems, has led to a search for scientific processes that are more compatible with this reality. As illustrated in Fig. 1, several research processes have emerged in recent years that entail a more scientifically acceptable approach to collecting social data. For example, Geisler (1993) has argued that ''ex ante'' research is not a sufficient source of data for understanding how management actions relate to social systems, but that an ongoing, process-oriented assessment approach is needed. This provides links to adaptive management processes, where scientific analysis is continuous and used to evaluate the outcomes of management decisions and to revise and improve future management actions (Walters and Holling 1990, Lee 1993, Gunderson et al. 1995, Mangel et al. 1996).

Another example is strategic perspectives analysis

(Dale and Lane 1994), a flexible procedure that can be used both to conduct participatory processes and to help integrate results of social assessment with resource planning. This approach, developed in Australia to assess Aboriginal participation in planning for rural economic development, uses ethnographic techniques to identify existing and potential resource uses and interests. Stakeholders who are thus identified are then invited to participate in the research process by formulating their own preferred land use strategies and to consider those strategies in relation to others in the planning community and to different land management scenarios.

The emphasis on adaptive management within ecosystem management has resulted from a search for organizational processes that place less emphasis on exercising control and more emphasis on generating meaning and enabling responsive action (Lee 1993). Research in the field of business management contains valuable insights into organizational structures, strategic processes, sources of innovation, interorganizational collaboration, and organizational revitalization that may have useful applications to ecosystem management strategies (e.g., Wheatley 1994, Westley 1995). One conclusion drawn from this literature is that there is an intimate connection between the dynamics of social systems and those of ecosystems, and that the same means must be employed to create organizations capable of managing ecosystem resiliency and organizations capable of resiliency in their own right (Westley 1995). Adaptive management, then, should be seen not only as a scientific process by which we respond to ecological and social change, but also as a scientific process through which we reflect upon our processes of response.

Using Social Data in an Adaptive Management Program

The framework outlined in Fig. 1 is not designed to provide a complete listing of public involvement and social analysis approaches that may apply to ecosystem management. It was designed to illustrate the differences between public involvement and social science analysis, to show that they have both data and process considerations that need to be taken into account in ecosystem management, and to illustrate some of the major types of process and data considerations that are commonly applied. Depending on circumstances, some social science information sources will be critical and others will be marginal or inapplicable. The types of decisions that must go into identifying and collecting relevant social information and the use of the information in ecosystem management must be made in a context of adaptive management and social learning (Lee 1993).

A sample social learning/adaptive management process

Specific ecosystem management decisions will vary greatly depending on project size and goals, critical public issues, and the time frame and available resources (e.g., data, expertise, and financing). This will result in different sets of stakeholders and data analysis needs across management settings. Agency decisions regarding data and process needs should not be made without expert input and public involvement. While no one single process for meeting the goals of adaptive management and social learning will apply to every different situation, we illustrate one approach for meeting this dual goal within a general ecosystem management framework.

Decisions that must be made at the onset of an ecosystem management project include: (1) the project scale or zone of social and biological influence; (2) the most relevant biophysical data that will be needed for decision making; (3) the most relevant social data and stakeholder information that will be needed for decision making; (4) a prioritization of the social and biophysical data needs (because no decision process will be able to collect all relevant data); and, (5) indicators and standards for monitoring social and biophysical factors to meet adaptive management needs. These decisions should be made at the outset of the project using a collaborative learning effort between resource professionals, scientists, and the public. One way to do this is to combine a modified Delphi process with public involvement. (The Delphi method is an iterative group interview process whereby anonymous responses are solicited from a group of people, those people are then presented with results of the group's responses and asked to reconsider and respond again, and the alteration of anonymous input and reporting of results can be repeated several times. The process gives participants equal input and enables them to alter their opinions without losing face.)

First, social and biophysical scientists are selected who have experience in resource management. They are included in a Delphi panel with key resource managers from relevant agencies and local ''experts.'' A summary of the ecosystem planning or management problem is presented to this group by mail, and they are asked to identify factors such as: (1) the relevant scale of social and biophysical analysis; (2) social and biophysical data needs; (3) relevant stakeholders and variables that will explain linkages between the ecosystem and stakeholder groups; and (4) the most important indicators for adaptive management. Depending on the diversity of responses, two or three iterations of the Delphi process (where results of previous rounds are sent to participants for their further response) should be completed.

Next a series of workshops could be conducted with the Delphi panel participants along with people from local communities and affected subgroups to review, critique, and revise the analysis framework developed by the Delphi panel. This would include a prioritization of the process and analysis needs, and more rigorous development of standards and indicators for adaptive management. Adaptive management standards can also be prioritized by biophysical, social, or administrative importance, and other factors (e.g., data availability) critical for the long-term implementation and monitoring of the ecosystem management program.

Social learning takes place in this process in several ways. First, agency professionals hear from many different sources outside the agency about the relative emphasis on social and biophysical data. Second, the iterative Delphi process allows panelists with professional training to learn from each other. Finally, stakeholder and expert interaction encourages the consideration of both scientific and policy considerations in the ecosystem management planning process.

Such a Delphi/public involvement process can help analysts meet many of the characteristics of ecosystem management (e.g., planning at different scales and integrating social and biophysical factors), as well as meeting social learning and adaptive management needs critical to ecosystem management (Lee 1993). Other ecosystem management needs, such as identifying desired future conditions or specific sustainability objectives, can also be built into this process. Other ways of collecting this information (perhaps before the Delphi/public involvement process) may also be devised that better fit individual decision situations.

The process described above is not the only social process needed during ecosystem management decision-making and implementation. Ongoing use of public involvement and social science approaches is needed throughout project planning and implementation. In fact, the U.S. Forest Service's Human Dimensions of Ecosystem Management Task Force has been developing a very detailed, systematic process for combining public involvement and social science approaches throughout the process of planning and implementing ecosystem management. For example, if Native Americans have used the project area for hunting, gathering, or religious activities, their local indigenous knowledge would constitute important data needed for the project. This may take place as a collaborative learning effort with specific tribal representatives, or a more systematic social science effort may be needed if there are many different products collected by several subgroups. If these traditional uses of resources are central to the ecosystem management project goals (e.g., plant species being collected are moving toward threatened status), a more intensive public involvement process such as collaborative partnerships with tribal leaders may be critical for implementing the project and for long-term monitoring and adaptive management.

The NEPA experience of the last 30 yr has taught us that monitoring is often ignored after project implementation because other agency mandates, expenses, and issues demand staff attention. But to meet ecosystem management objectives, there should be monitoring of certain key variables for all ecosystem management projects. The decision framework in Fig. 1 can help in this regard as well. The public involvement and social analysis needs identified in the early stage of an ecosystem management project should become a joint effort of the agencies, experts, and stakeholders involved in the project. For example, collecting certain types of data may be a role for stakeholders and, if necessary, contingent or alternative management scenarios may be devised in collaboration with those same stakeholders. Once again, the information needed for adaptive management is likely to include biophysical data (e.g., status of endangered plants) as well as social science data (e.g., change in recreation benefit patterns), with the exact mix determined by project characteristics.

Integrating Public Involvement and Social Analysis

The processes of public involvement and social analysis need to be linked to make the best use of the data from both activities (Blahna and Yonts-Shepard 1989, Burdge 1990). Public involvement processes are important sources of social science data that may provide insights into conflicting goals facing resource managers or government decision makers. Due to limited agency budgets and Office of Management and Budget procedures governing survey research, public involvement data often is an important source of readily available information, and it is not always adequately utilized for the potential insights it can provide. Yet due to its uncontrolled partiality, public involvement processes are usually inadequate sources of data for describing the richness and breadth of human responses to environments and proposed ecosystem manipulations, and thus social science analysis is needed to fill in the gaps. At the same time, the social scientific process may not be responsive to practical management issues because of social scientists' disciplinary concerns and the cost and timing required for thorough data collection. Public involvement methods may be able to respond more directly to management concerns and may be needed in order to make the kinds of rapid shifts required by adaptive management. Neither mode of learning is sufficient unto itself for effective ecosystem management.

These two social scientific components of ecosystem management represent key dimensions of the process that has been referred to as "social learning." It incorporates multiple ways of knowing, acknowledging the limitations of traditional social scientific inquiry, just as natural resource managers are learning to incorporate local ecological knowledge into their understanding of ecosystems (e.g., Krishnaswamy 1995). It also acknowledges the importance of both the information-gathering process and the data themselves in forming a more complete picture of the complex relationships of humans in ecosystems. While we advocate consideration of all four of the major process and data categories set forth in Fig. 1 in any analysis of ecosystem management options, we also recognize that the exact mixture of forms of social inquiry will vary with circumstances such as the immediacy of the need to act, funds available for scientific research, the depth and breadth of public concern over the ecosystem in question, and the availability of various forms of secondary data. Moreover, we do not mean to suggest that social scientists presently know enough about how to accomplish each of these tasks. For example, considerable work is needed to develop ways to more effectively engage a full range of stakeholders in civic dialogue about social values and environmental concerns.

The final (and perhaps greatest) challenge is to integrate this social knowledge with the body of ecological knowledge about the ecosystems under study. Integration both across social science disciplines (e.g., economics and sociology) and between social and natural science perspectives is a significant obstacle that needs to be addressed. In the short term, this challenge might best be addressed through implementation of intensive interdisciplinary training programs designed to give practicing resource management professionals a basic, foundation-level exposure to a broad array of disciplinary learning applicable to ecosystem management. Programs such as the Continuing Education in Ecosystem Management training course organized by federal resource management agencies and several western U.S. universities can provide short-term improvements in the capacity of agency personnel to accomplish improved integration.

Over the longer term, there is a need for significant redirection of academic training programs away from traditional disciplinary specialization and toward broad-based interdisciplinary learning that will allow social and natural scientists to more effectively communicate with one another in the pursuit of integrated ecosystem analyses. We need to find a common language for interaction between social and ecological scientists and practitioners, and to identify compatible measures at appropriate spatial and temporal scales. Doing so will require both formal research and adaptive management (e.g., Kessler et al. 1992). For example, interdisciplinary research might be the best approach for identifying feedback effects of human uses on ecosystems and of subsequent changes in ecosystem structure and function on human social organization, while adaptive management might be a better way to evaluate compatibility of data at different scales. Finally, we need to address the relationships between the politics and the science of ecosystem management, seeking ways to enhance the ability of ecosystem science to inform and guide actions and decisions that are inherently situated in political processes. Meeting these challenges will require a substantial expansion of social science elements in ecosystem analysis and planning.

Acknowledgments

The authors wish to acknowledge the support of the Utah Agricultural Experiment Station, Utah State University, Logan, Utah 84322-4810. (Approved as AES Journal Paper Number 6090.) The authors would also like to thank Bev Driver of the Rocky Mountain Forest Experiment Station and Deborah Carr of the North Central Forest Experiment Station for assistance in the development of the literature and ideas presented in this paper.

Literature Cited

American Forest and Paper Association. 1995. Sustainable forestry: principles and implementation guidelines. Washington, D.C., USA.

Amy, D. 1987. The politics of environmental mediation. Columbia University Press, New York, New York, USA.

Bell, A. 1994. Non-human nature and the ecosystem approach: the limits of anthropocentrism in Great Lakes management. Alternatives **20**(3):20.

Berkes, F., and P. George. 1991. Co-management: the evolution in theory and practice of the joint administration of living resources. Alternatives **18**(2)12–18.

Bingham, G. 1986. Resolving environmental disputes: a decade of experience. The Conservation Foundation, Washington, D.C., USA.

Blahna, D. J. 1995. Integrating social and biophysical factors in ecosystem management: quest for the philosopher king. Pages 507–512 *in* J. L. Thompson, D. W. Lime, B. Gartner, and W. M. Sames, compilers. Proceedings of the Fourth International Outdoor Recreation and Tourism Trends Symposium and the 1995 National Recreation Resource Planning Conference. University of Minnesota, College of Natural Resources, St. Paul, Minnesota, USA.

Blahna, D. J., and S. Yonts-Shepard. 1989. Public involvement in resource planning: toward bridging the gap between policy and implementation. Society and Natural Resources **2**:209–227.

Blahna, D. J., and S. Yonts-Shepard. 1990. Preservation or use? Confronting public issues in forest planning and decision making. Pages 161–176 *in* J. Hutcheson, F. Noe, and R. Snow, editors. Outdoor recreation policy: pleasure and preservation. Greenwood, New York, New York, USA.

Bonnicksen, T. 1991. Managing biosocial systems: a framework to organize society-environment relationships. Journal of Forestry **89**(10):10–15.

Branch, K., D. Hooper, J. Thompson, and J. Creighton. 1984. Guide to social assessment. Westview Press, Boulder, Colorado, USA.

Brandenburg, A. M., and M. S. Carroll. 1995. Your place or mine? The effect of place creation on environmental values and landscape meanings. Society and Natural Resources **8**: 381–398.

Brown, T. C., and T. C. Daniel. 1986. Predicting scenic beauty of timber stands. Forest Science **33**:394–410.

Brunson, M. 1993. ''Socially acceptable'' forestry: what does it imply for ecosystem management? Western Journal of Applied Forestry **8**:116–119.

Brunson, M. W., D. T. Yarrow, S. D. Roberts, D. C. Guynn Jr., and M. R. Kuhns. 1996. Nonindustrial private forest owners and ecosystem management: can they work together? Journal of Forestry **94**(6):14–21.

Burch, W. R., Jr., and D. R. DeLuca. 1984. Measuring the social impact of natural resource policies. University of New Mexico Press, Albuquerque, New Mexico, USA.

Burdge, R. J. 1987. The social impact assessment model and the planning process. Environmental Impact Assessment Review **7**:141–150.

———. 1990. Utilizing social impact assessment variables in the planning model. Impact Assessment Bulletin **8**:85–100.

Bureau of Land Management. 1994. Ecosystem management in the BLM: from concept to commitment. BLM Information Bulletin **94-191**.

Burgess, R. L. 1993. Ecosystems in space and time. Pages

81–87 *in* D. C. LeMaster and G. R. Parker, editors. Ecosystem management in a dynamic society: proceedings of a conference in West Lafayette, Indiana, 19–21 November 1991. Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana, USA.

Carr, D. S. 1995. Human dimensions of ecosystem management: a U.S. Forest Service perspective. Pages 19–22 *in* D. J. Chavez, editor. Proceedings of the Second Symposium on Social Aspects and Recreation Research. Publication available through the Rocky Mountain Research Station, Ft. Collins, Colorado, USA. U.S. Forest Service General Technical Report **PSW-156.**

Catton, W. R., and R. E. Dunlap. 1980. A new ecological paradigm for post-exuberant sociology. American Behavioral Scientist **24**:15–47.

Christensen, N. L., A. M. Bartuska, S. Carpenter, C. D'Antonio, R. Francis, J. F. Franklin, J. A. MacMahon, R. F. Noss, D. J. Parson, C. H. Peterson, M. G. Turner, and R. G. Woodmansee. 1996. The report of the Ecological Society of America committee on the scientific basis for ecosystem management. Ecological Applications **6**:665–691.

Covington, W. W., and L. F. DeBano, technical coordinators. 1994. Sustainable ecological systems: implementing an ecological approach to land management. U.S. Forest Service General Technical Report **RM-247.**

Crowfoot, J., and J. Wondolleck. 1990. Environmental disputes: community involvement in conflict resolution. Island Press, Washington, D.C., USA.

Dale, A. P., and M. P. Lane. 1994. Strategic perspectives analysis: a procedure for participatory and political social impact assessment. Society and Natural Resources **7**:253–267.

Daniels, S. E., and G. B. Walker. 1995. Managing local environmental conflict amidst national controversy. International Journal of Conflict Management **6**(3):290–311.

Daniels, S. E., G. B. Walker, J. R. Boeder, and J. E. Means. 1994. Managing ecosystems and social conflict. Pages 327–339 *in* M. E. Jensen and P. S. Bourgeron, editors. Volume II: ecosystem management: principles and applications. U.S. Forest Service General Technical Report **PNW-318**.

De Lacy, T. 1994. The Ulu*r*u/Kakadu model—A*n*angu Tjukurrpa. Society and Natural Resources **7**:479–498.

Doak, S. C., and J. Kusel. 1996. Well-being in forest-dependent communities, Part II: a social assessment focus. Chapter 13 in Sierra Nevada Ecosystem Project: final report to Congress. Volume II: Assessments and scientific basis for management options. Centers for Water and Wildland Resources, University of California, Davis, California, USA.

Edelstein, M. R., and D. A. Kleese. 1995. Cultural relativity of impact assessment: Native Hawaiian opposition to geothermal energy development. Society and Natural Resources **8**(1):19–31.

Endter, J. L. 1987. Cultural ideologies and the political economy of water in the United States West: Northern Ute Indians and rural Mormons in the Uintah Basin, Utah. Dissertation. University of California, Irvine, California, USA.

Endter-Wada, J., and D. W. Levine. 1996. Comparison of subsistence activities among Natives and non-Natives in Bristol Bay, Alaska. Society and Natural Resources **9**(6): 595–609.

Endtar-Wada, J., and R. J. Lilieholm, editors. 1995. Proceedings of the Symposium: Conflicts in Natural Resources Management: Integrating Social and Ecological Concerns. Natural Resources and Environmental Issues, Volume 3. College of Natural Resources, Utah State University, Logan, Utah, USA.

Endter-Wada, J., L. A. Robbins, D. W. Levine, D. L. Boxberger, P. D. Nohalty, J. G. Jorgensen, and S. L. McNabb. 1992. Bristol Bay subsistence harvest and sociocultural systems inventory. Outer Continental Shelf Study, MMS 92-0036, Technical Report Number 150. U.S. Department of the Interior, Minerals Management Service, Alaska OCS Regional Office, Anchorage, Alaska, USA.

Environmental News Network staff. 1993. Clinton team promoting ecosystem management. Environmental News Briefing, **1**(13):1–2.

Everett, R. L., and D. Baumgartner, compilers. 1995. Ecosystem management in Western interior forests (symposium proceedings). Cooperative Extension, Washington State University, Pullman, Washington, USA.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Joint publication of the United States Department of Agriculture: Forest Service; United States Department of Commerce: National Oceanic and Atmospheric Administration and National Marine Fisheries Service; United States Department of the Interior: Bureau of Land Management, Fish and Wildlife Service, and National Park Service; and United States Environmental Protection Agency, Washington, D.C., USA.

Field, D. R., and W. R. Burch, Jr. 1988. Rural sociology and the environment. Sociology Ecology Press, Middleton, Wisconsin, USA.

Freudenburg, W. R., and K. M. Keating. 1985. Applying sociology to policy: social science and the environmental impact statement. Rural Sociology **50**:578–605.

Frisbie, W. P., and D. L. Poston, Jr. 1978. Sustenance organization and migration in nonmetropolitan America. University of Iowa Press, Iowa City, Iowa, USA.

Frissell, C., R. Nawa, and R. Noss. 1992. Is there any conservation biology in ''New Perspectives?'': a response to Salwasser. Conservation Biology **6**:461–464.

Geisler, C. C. 1993. Rethinking SIA: why ex ante research isn't enough. Society and Natural Resources **6**:327–338.

Gobster, P. H. 1995. Aldo Leopold's ''ecological aesthetic'': integrating aesthetic and biodiversity values. Journal of Forestry **93**(2):6–10.

Greater Yellowstone Coordinating Committee. 1990. Draft vision for the future: a framework for coordination in the Greater Yellowstone area. Billings, Montana, USA.

Greider, T., and L. Garkovich. 1994. Landscapes: the social construction of nature and the environment. Rural Sociology **59**:1–24.

Grumbine, R. E. 1994. What is ecosystem management? Conservation Biology **8**:27–38.

Guldin, J. M., and D. Henderson. 1993. Final workshop report: social context research planning. Final report of the proceedings of the Social Context Research Planning Workshop, 13–15 July 1992. Winrock International, Morrilton, Arkansas, USA.

Gunderson, L. H., C. S. Holling, and S. S. Light, editors. 1995. Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, New York, USA.

Harris, C., G. Brown, and B. McLaughlin. 1996. An assessment of the social and economic characteristics of communities in the Interior Columbia River Basin. Interior Columbia Basin Ecosystem Management Project, U.S. Forest Service, Walla Walla, Washington, USA.

Harwell, M. A., J. F. Long, A. M. Bartuska, J. H. Gentile, C. C. Harwell, V. Myers, and J. C. Ogden. 1996. Ecosystem management to achieve ecological sustainability: the case of South Florida. Environmental Management **20**:497–521.

Haynes, R. W., R. T. Graham, and T. M. Quigley, editors. 1996. A framework for ecosystem management in the Interior Columbia Basin. U.S. Forest Service General Technical Report **PNW-374**.

Heberlein, T. A. 1976. Some observations on alternative mechanisms for public involvement: the hearing, public opinion poll, the workshop and the quasi-experiment. Natural Resources Journal **16**:197–212.

Howell, R. E., E. O. Marvin, and D. Olsen. 1987. Designing a citizen involvement program: a guidebook for involving citizens in the resolution of environmental issues. Western Rural Development Center, Oregon State University, Corvallis, Oregon, USA.

Human Dimension Study Group. 1994. The human dimension in sustainable ecosystem management: a management philosophy. U.S. Forest Service Southwestern Region and Rocky Mountain Forest and Range Experiment Station, Albuquerque, New Mexico, USA.

Interagency Ecosystem Management Task Force. 1995. The ecosystem approach: healthy ecosystems and sustainable economies. U.S. Department of the Interior, Washington D.C., USA.

Interorganizational Committee on Guidelines and Principles for Social Impact Assessment. 1993. Guidelines and principles for social impact assessment. International Association for Impact Assessment, Belhaven, North Carolina, USA.

Iverson, D. C. 1994. A shared approach to ecosystem management. Pages 129–134 *in* Foresters together: meeting tomorrow's challenges. Proceedings of the Society of American Foresters National Convention, Indianapolis, Indiana, 7–10 November 1993. Society of American Foresters, Bethesda, Maryland, USA.

Jensen, M. E., and P. S. Bourgeron, editors. 1994. Volume II: ecosystem management: principles and applications. U.S. Forest Service General Technical Report **PNW-318**.

Jorgensen, J. G. 1972. The Sun Dance religion: power for the powerless. University of Chicago Press, Chicago, Illinois, USA.

———. 1978. A century of political economic effects on American Indian society: 1880–1980. Journal of Ethnic Studies **6**:1–82.

———. 1984. Land is cultural, so is a commodity: differences among Indians, cowboys, sodbusters, and environmentalists. Journal of Ethnic Studies **12**(3):1–21.

———. 1990. Oil Age Eskimos. University of California Press, Berkeley, California, USA.

———. 1995. Ethnicity, not culture: obfuscating social science in the Exxon Valdez Oil Spill case. American Indian Culture and Research Journal **19**(4):1–124.

Kaplan, R., and S. Kaplan. 1989. The experience of nature. Cambridge University Press, Cambridge, UK.

Kaufmann, M. R., R. T. Graham, D. A. Boyce Jr., W. H. Moir, L. Perry, R. T. Reynolds, R. L. Bassett, P. Mehlhop, C. B. Edminster, W. M. Block, and P. S. Corn. 1994. An ecological basis for ecosystem management. U.S. Forest Service General Technical Report **RM-246**.

Kemmis, D. 1990. Community and the politics of place. University of Oklahoma Press, Norman, Oklahoma, USA.

Kennedy, J. J. 1991. Integrating gender diverse and interdisciplinary professionals into traditional U.S. Department of Agriculture-Forest Service culture. Society and Natural Resources **4**:165–176.

Kennedy, J. J., and T. M. Quigley. 1993. Evolution of Forest Service organizational culture and adaptation issues in embracing ecosystem management. Pages 16–26 *in* M. E. Jensen and P. S. Bourgeron, editors. Volume II: Ecosystem management: principles and applications. U.S. Forest Service General Technical Report **PNW-318**.

Kessler, W. B., H. Salwasser, C. W. Cartwright, Jr., and J. A. Kaplan. 1992. New perspectives for sustainable natural resources management. Ecological Applications **2**:221–225.

Krannich, R. S., M. S. Carroll, S. E. Daniels, and G. B. Walker. 1994. Incorporating social assessment and public involvement processes into ecosystem-based management: applications to the East Side Ecosystem Management Project. U.S. Forest Service Interior Columbia Basin Ecosystem Management Project, Walla Walla, Washington, USA.

Krishnaswamy, A. 1995. Sustainable development and community forest management in Bihar, India. Society and Natural Resources **8**:339–350.

Lackey, R. T. 1996. Seven pillars of ecosystem management. Landscape and Urban Planning, *in press.*

Lawrence, N., and D. Murphy. 1992. New perspectives or old priorities? Conservation Biology **6**:465–468.

Lee, K. 1993. Compass and gyroscope: integrating science and politics for the environment. Island Press, Washington, D.C., USA.

LeMaster, D. C., and G. R. Parker, editors. 1993. Ecosystem management in a dynamic society: proceedings of a conference in West Lafayette, Indiana, 19–21 November 1991. Department of Forestry and Natural Resources, Purdue University, West Lafayette, Indiana, USA.

Ludwig, D. 1993. Environmental sustainability: magic, science, and religion in natural resource management. Ecological Applications **3**:555–558.

Mangel, M., et al. 1996. Principles for the conservation of wild living resources. Ecological Applications **6**:338–362.

McDonnell, M. J., and S. T. A. Pickett, editors. 1993. Humans as components of ecosystems: the ecology of subtle human effects and populated areas. Springer-Verlag, New York, New York, USA.

Moote, M. A., S. Burke, H. J. Cortner, and M. G. Wallace. 1994. Principles of ecosystem management. Water Resources Research Center, University of Arizona, Tucson, Arizona, USA.

Moran, E. F., editor. 1990. The ecosystem approach in anthropology: from concept to practice. University of Michigan Press, Ann Arbor, Michigan, USA.

National Task Force on the Human Dimensions of Ecosystem Management. 1994. Implementing the social component of ecosystems management. Review draft report. U.S. Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado, USA.

Norton, B. G. 1991. Toward unity among environmentalists. Oxford University Press, New York, New York, USA.

Noss, R., and A. Cooperrider. 1994. Saving nature's legacy: protecting and restoring biodiversity. Island Press and Defenders of Wildlife, Washington, D.C., USA.

Ocean Studies Board and National Research Council. 1995. Science, policy, and the coast: improving decisionmaking. Committee on Science and Policy for the Coastal Ocean (Ocean Studies Board) and the Commission on Geosciences, Environment, and Resources (National Research Council). National Academy Press, Washington, D.C., USA.

Office of Technology Assessment. 1992. Forest Service planning: accommodating uses, producing outputs, and sustaining ecosystems. U.S. Government Printing Office, Washington, D.C., USA.

Owen-Smith, R. N. Megafaunal extinctions: the message from 11,000 B.C. Conservation Biology **3**:405–411.

Preister, K. 1994. Words into action: a community assessment of the Applegate Valley. Rogue Institute for Ecology and Economy, Ashland, Oregon, USA.

Quigley, T. M., R. W. Haynes, and R. T. Graham, editors. 1996. Integrated scientific assessment for ecosystem management in the Interior Columbia Basin. U.S. Forest Service General Technical Report **PNW-382**.

Reading, R. P., T. W. Clark, and S. R. Kellert. 1994. Attitudes and knowledge of people living in the Greater Yellowstone Ecosystem. Society and Natural Resources **7**:394–410.

Salwasser, H. 1991. New perspectives for sustaining diversity in U.S. national forest ecosystems. Conservation Biology **5**:567–569.

———. 1992. From New Perspectives to ecosystem management: response to Frissell et al. and Lawrence and Murphy. Conservation Biology **6**:469–472.

Shepard, W. B. 1993. Modern forest management: it's about opening up, not locking up. Pages 218–227 *in* W. W. Covington and L. F. DeBano, technical coordinators. Sustainable ecological systems: implementing an ecological approach to land management. U.S. Forest Service General Technical Report **RM-247**.

Shindler, B., B. Steel, and P. List. 1996. Public judgments of adaptive management: a response from forest communities. Journal of Forestry **94**(6):4–12.

Slocombe, D. S. 1993. Implementing ecosystem-based management: development of theory, practice and research for planning and managing a region. BioScience **43**:612–622.

Soule, M. 1991. Conservation: tactics for a constant crisis. Science **253**:744–750.

Southern Appalachian Man and Biosphere Cooperative. 1996. The Southern Appalachian assessment: social/cultural/economic technical report. Report 4 of 5. Coordinated through the Southern Appalachian Man and Biosphere Cooperative. U.S. Forest Service, Southern Region, Atlanta, Georgia, USA.

Stanley, T. R. 1995. Ecosystem management and the arrogance of humanism. Conservation Biology **9**:255–262.

Stuebner, S. 1997. Columbia Basic plan staggers home. High Country News **29**(2):7.

Super, G., G. Bower, V. Chambers, D. Carr, J. Osborn, B. Driver, K. Cordell, G. Flora, H. Mittmann, S. Galliano, W. Bacon, C. Manning, S. Yonts-Shepards. 1993. The human dimensions of national forest ecosystem management: an issue paper (Draft). Prepared by the Human Dimensions Task Group. White paper prepared for the Integrated Ecological and Resource Inventories Workshop. U.S. Department of Agriculture, Washington, D.C., USA.

Thomas, J. W. 1995. Engaging people in communities of interests. The 1995 C. Eugene Farnsworth Memorial Seminar. New York Center for Forestry Research and Development, SUNY College of Environmental Science and Forestry, Syracuse, New York, USA.

U.S. Fish and Wildlife Service. 1994. Desert Tortoise (Mohave Population): recovery plan. Prepared by the Desert Tortoise Recovery Team, U.S. Fish and Wildlife Service, Portland, Oregon, USA.

U.S. Forest Service. 1994. A national framework: ecosystem management. Washington, D.C., USA.

———. 1995. The Forest Service program for forest and rangeland resources: a long-term strategic plan. Draft 1995 RPA Program. Washington, D.C., USA.

———. 1996. Status of the Interior Columbia Basin: summary of scientific findings. U.S. Forest Service General Technical Report **PNW-385**.

Wagner, F. H. 1996. Principles for the conservation of wild living resources: another perspective. Ecological Applications **6**:365–367.

———. 1995. Epilogue: what have we learned? Pages 121–125 *in* F. H. Wagner, editor. 1995. Proceedings of the symposium: ecosystem management of natural resources in the Intermountain West. Natural Resources and Environmental Issues, Volume 5. College of Natural Resources, Utah State University, Logan, Utah, USA.

———, editor. 1995. Proceedings of the symposium: ecosystem management of natural resources in the Intermountain West. Natural Resources and Environmental Issues, Volume 5, College of Natural Resources, Utah State University, Logan, Utah, USA.

Wagner, F. H., and C. E. Kay. 1993. ''Natural'' or ''healthy'' ecosystems: are U.S. national parks providing them? Pages 257–270 *in* M. J. McDonnell and S. T. A. Pickett, editors. Humans as components of ecosystems: the ecology of subtle human effects and populated areas. Springer-Verlag, New York, New York, USA.

Walker, G. B., and S. E. Daniels. 1996. The Clinton administration, the Northwest forest conference, and managing conflict: when talk and structure collide. Society and Natural Resources **9**:77–91.

Walters, C. J., and C. S. Holling. 1990. Large-scale management experiments and learning by doing. Ecology **71**: 2060–2078.

Wenner, L. N. 1987. The practice and promise of social science in the U.S. Forest Service. Pages 63–82 *in* M. L. Miller, R. P. Gale, and P. J. Brown, editors. Social science in natural resource management systems. Westview, Boulder, Colorado, USA.

West, P. C. 1994. Natural resources and persistence of rural poverty in America: A Weberian perspective on the role of power, domination, and natural resource bureaucracy. Society and Natural Resources **7**:415–428.

West, P. C., and S. R. Brechin, editors. 1991. Resident peoples and national parks. University of Arizona Press, Tucson, Arizona, USA.

Westley, F. 1995. Governing design: the management of social systems and ecosystem management. Pages 391–427 *in* L. H. Gunderson, C. S. Holling, and S. S. Light, editors. Barriers and bridges to the renewal of ecosystems and institutions. Columbia University Press, New York, New York, USA.

Wheatley, M. J. 1994. Leadership and the new science: learning about organization from an orderly universe. Berrett-Koehler, San Francisco, California, USA.

Wiant, H. V., Jr. 1995. Ecosystem management: retreat from reality. Forest Farmer (September/October):20–23.

Wilkinson, K. P. 1991. The community in rural America. Greenwood, New York, New York, USA.

Wood, C. 1994. Ecosystem management: achieving the new land ethic. Renewable Resources Journal **12**:6–12.

Yaffee, S. L. 1994. The wisdom of the spotted owl: policy lessons for a new century. Island Press, Washington, D.C., USA.

Yaffee, S. L., A. F. Phillips, I. C. Frents, P. W. Hardy, S. M. Malecki, and B. E. Thorpe. 1996. Ecosystem Management in the United States: an assessment of the current experience. Island Press, Washington, D.C., USA.

Young, T. P., N. Partridge, and A. Macrae. 1995. Long-term glades in acacia bushland and their edge effects in Laikipia, Kenya. Ecological Applications **5**:97–108.

ERRATUM

In the article by A. C. Finzi, C. D. Canham, and N. Van Breeman entitled ''Canopy tree–soil interactions within temperate forests: species effects on pH and cations,'' published in *Ecological Applications* 8(2): 447–454, Fig. 2 appeared with incorrect *y*-axis labels, due to an unfortunate printing error. The correct figure is reprinted below. The figure shows the content of exchangeable cations beneath six different canopy tree species growing in mixed-species forests in northwestern Connecticut. The differences among species in base vs. acid cations are highly correlated with soil pH. Soil pH is highest under sugar maple and lowest beneath hemlock.

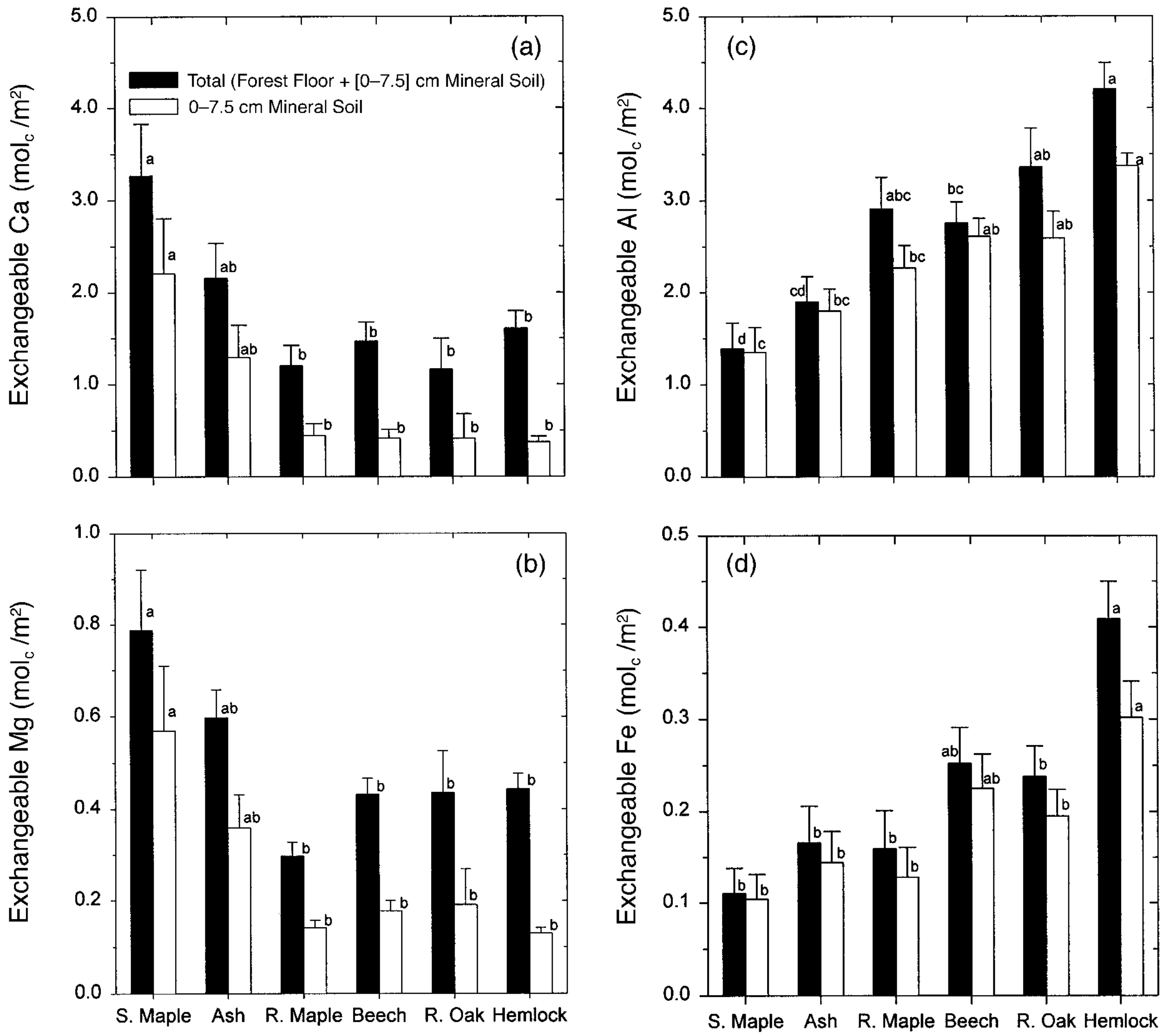

FIG. 2. Mean quantities [mol$_c$/m^2 ± 1 SE] of exchangeable Ca in the forest floor and top 7.5 cm of mineral soil beneath the different tree species. Bars with the same shading but with different letters are significantly ($P < 0.05$) different from one another. (a) Calcium, (b) magnesium, (c) aluminum, and (d) iron.