Evolving approaches toward science-based forest management

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Abstract

The scale, scope, and complexity of natural resource and environmental issues have dramatically increased, yet the urgency to solve these issues often requires immediate information that spans disciplinary boundaries, synthesizes material from a variety of sources, draws inferences, and identifies levels of confidence. Although science information and knowledge are only one consideration in natural resource decisions, credible science information is increasingly necessary to gain public support and acceptance. But what are the appropriate roles for science and scientists versus managers and policymakers in natural resource decisions? Scientists can provide managers and policymakers with the underlying information needed for making reasoned decisions. The prerequisites for science-based decision-making are understanding and appreciating what science can and cannot offer, fulfillment of the proper roles for the different participants, and evaluation of how science information is used in a decision. To be science-based, a decision must be made with the full consideration and correct interpretation of all relevant science information, and the scientific understanding must be revealed to all interested parties. Based on experience from the Pacific Northwest, a conceptual framework is presented that allows the development of research problems and components while facilitating communication among people interested in a variety of values.

Keywords: decision-making, science-based resource management, Pacific Northwest examples

1 Introduction

Using science as the basis for natural resource decision-making has undergone increased scrutiny and emphasis in the United States. Although science information and knowledge are only one consideration in natural resource decisions, credible science information is increasingly necessary to gain public support and acceptability (Mills *et al.* 2002). But the real challenge for scientists, policy makers, and the public at large, is that simply having the "best available scientific information" can lead to dramatically different results as the inferences drawn from scientific findings differ greatly (Bradshaw and Borchers 2000). For example, even unprecedented efforts such as the Intergovernmental Panel on Climate Change (IPCC 1990, 1996) appear to provide insufficient scientific guidance for the formulation of decisive environmental policy (Bradshaw and Borchers 2000). The importance of a scientific basis for decisions has been well recognized in other fields. Jasanoff (1990), for example, describes the experience that other agencies have had incorporating science with decision-making on topics such as health care and environmental protection.

But what are the appropriate roles for science and scientists, managers and policymakers in natural resource decisions? Scientists can provide managers and policymakers with the underlying information needed for making reasoned decisions (SHAW *et al.* 2000). They should advocate that the relevant scientific information be considered when a decision is made. This does not mean they should advocate a particular outcome, rather they should report what is the "state of the science" relative to the issue (FROSCH 2001). Furthermore, scientists should determine whether the decision is 'consistent' with the science information. Managers and policymakers, on the other hand, use scientific information, but must also balance legal mandates, societal desires, political objectives, policy considerations and other factors into their final decisions (SHAW *et al.* 2000). All policy decisions concerning the use of natural resources contain some level of risk to resources as a result of long-term implementation. When making decisions, managers strive to balance the array of risks associated with their decisions with the values of goods and services flowing to society from the managed lands. Such management decisions almost always include trade-offs and compromises for one or more resources. Furthermore, managers know full well that the outcomes of their implementations will again be scrutinized and judged by the public.

Full consideration of the relevant and available scientific information can help improve the decision-making process by providing an understanding of the natural and human systems and their interactions. A science foundation helps people understand a system in which they are all interested and improves their ability to estimate consequences and risks of decision alternatives (MILLS *et al.* 2002). Science insights may occasionally lead to a wider range of management alternatives that increase the potential compatibility among people holding differing values for how the land should be managed and used (MILLS *et al.* 2002).

Although science information does not direct any decisions, it is one set of vital information to consider before making a decision, especially on increasingly complex and value-laden issues. Full consideration of the best available science is an important foundation of the legal defense of decisions and adds to the credibility of the decision in the eyes of the public. More and more decision-makers are recognizing the need and value for science and learning in the decision-making process (see examples next page).

This paper examines the role of science in the decision-making process and presents a model for making decisions that balances the interactions among social values, institutions, management, and outcomes, with particular reference to the Pacific Northwest Forest Region of the United States of America.

2 Potential contributions of science to natural resource decisions

Given the value-laden conflict and increasingly polarized debate concerning the management of natural resources, science should play a large role in informing the choices made in the decision-making process (MILLS and CLARK 2001). MILLS and CLARK (2001) suggest scientific information can help better inform these difficult decisions in several ways. It can:

- help facilitate productive discussion among different and competing interests.
- help focus the discussion on choices and their consequences rather than on polarized positions.
- highlight the range of available choices, and may even lead to new options that balance competing interests.
- increase the understanding of management decisions and help lead to the expected outcomes.

Examples of the recognition of the need for science-based forest management.

– Forest Management Guidelines balance social, economic, and environmental objectives for forest resources. They take into account resource needs, landowner objectives, forest characteristics, existing regulations, economics, and the **best information** about forest resources available at any given time (State of Minnesota).
<http://www.frc.state.mn.us/ FMgdline/Guidelines.html#what_are>
– The Division of Forestry protects this resource and promotes its sustainable use through **science-based** forest management. Sustainable management emphasizes different uses of the forest in different situations, but always avoids destructive exploitation or lost opportunities due to neglect or ignorance (State of Tennessee).
<http://www.tennessee.gov/agriculture/forestry/>
– The Forest Practices Monitoring Program (FPMP) is **producing valuable information** for adapting forest management to better protect our natural resources and to serve the needs of the public and stakeholders (State of Oregon).
<http://www.odf.state.or.us/divisions/protection/forest_practices/fpmp/default.asp?id=20601>
– With the help of **science**, we began basing much of our management on watershed health. Today, the Forest Service no longer focuses on the most efficient, cost-effective way to remove timber. Instead, we focus on long-term ecosystem health, measured in terms of healthy watersheds (Dale Bosworth Chief, USDA Forest Service, Sept 18, 2002).
<http://www.fs.fed.us/news/2002/09/McClurerev3.3.rtf>
– Twenty years ago, we focused primarily on outputs, measured in terms of board feet of timber; today we focus primarily on outcomes, measured in terms of healthy ecosystems. We've **learned** that what we leave on the land is more important than what we take away (Dale Bosworth, Chief, USDA Forest Service, March 27, 2003).
<http://www.fs.fed.us/news/2003/speeches/wildlife.pdf>

3 Elements of science-based decision-making

Although the desirability of "science-based" decisions has been recognized (e.g., Committee of Scientists 1999; MILLS and CLARK 2001), what that actually means is not clear. The prerequisites for science-based decision-making are understanding and appreciating what science can and cannot offer and evaluation of how science information is used in a decision. The following elements are proposed for ensuring science-based decision-making (modified from MILLS *et al.* 2002):

Science information is viewed as the basis for the forest management decision-making process: Understanding and applying relevant science helps land managers and publics evaluate the status of ecosystems and the risks of management decisions to those ecosystems, identify goals that are sustainable, evaluate the effects of proposed activities, and reconcile competing values. The scientific community applies their detailed knowledge of scientific methods and concepts to help managers and the public identify the appropriate temporal and spatial scales for addressing issues, determine whether all relevant information is being considered, evaluate whether that information is being interpreted in a manner consistent with current scientific understanding, understand the scientific limits to predict the future, and ensure that uncertainty is recognized. Broad acceptance of credible scientific information contributes to increased public consensus about the management of forests.

Science information is readily available and presented in a manner that facilitates easy use: There are many examples of science information that has been synthesized into policy-relevant packages (e.g., CLARK *et al.* 1998; FEMAT 1993; Sierra Nevada Ecosystem Project Science Team and Special Consultants 1996; Southern Appalachian Man and the Biosphere Cooperative 1996a, 1996b, 1996c, 1996d, 1996e; SWANSTON 1997, University of California 1996a, 1996b, 1996c) and presented in ways that are readily understandable by all interested parties (e.g., JULIN and SHAW 1999; QUIGLEY and BIGLER-COLE 1997; SWANSTON *et al.* 1996). Science assessments are one example of synthesis of understanding about a particular system and its associated issues. Assessments also include estimates of the likely consequences of possible management options. They identify areas of risk and estimate risk levels in achieving the policy goals (e.g., QUIGLEY and ARBELBIDE 1997; QUIGLEY *et al.* 1996). Finally, "the scientific credibility of the assessment process will be questioned at every conceivable opportunity, so managers need to be prepared to defend the assessment" (WINSTANLEY *et al.* 1998).

Science information is fully used and considered in making natural resource management decisions: Professional staff and the decision-maker are aware of the relevant science information. They understand the relationships presented in the science documents. Decision-makers and professional staff use that knowledge and understanding to design management options and estimate the consequences of these options. The decision-maker reveals the consequences of the final decision, and those consequences are consistent with the relations revealed in the science information.

Science information is used in a consistent manner in major land management decisions with its use evaluated and documented: The decision-maker ensures that the decision is consistent with science. This is accomplished ideally by independent review that evaluates whether the information and rationale underlying the final decision are consistent with available science information. The evaluation determines whether the available scientific information was considered as the decision was being made and whether the revealed consequences, including risk, of the final decision are consistent with available scientific information (e.g., EVEREST *et al.* 1997).

Science information is recognized as important but only as one of the pieces of information considered in a decision: Science information is just that, "information". It alone does not direct a decision. Scientists should not advocate a particular solution to the policy or management issue (MILLS and CLARK 2001). Any decision will require integration of many considerations of which science information is only one. Those other factors that lead to a decision are fully revealed so that the logic trail from all the information to the final decision is clear. This value-based balancing of all information relevant to making a decision is the stuff of decision-making.

4 Barriers to science-based decision-making

There are several barriers that must be dealt with in order to achieve science-based decision-making (modified from MILLS *et al.* 2002):

Cultural differences between research and policy-making processes are significantly different: The role of the decision-maker is to make choices among the available options and to seek common ground and agreement. The decision-maker makes what are primarily value choices among divergent tradeoffs and seeks consensus. The research culture, on the other hand, demands sound scientific methods, independence, and repeatability and embraces debate among competing ideas. These cultural differences are substantial, especially in how information is treated and the priority placed on agreement. Once recognized, however, the productive tension of these differences can often be harnessed to generate a synergy that is not available from either cultural perspective alone.

Researchers sometimes inappropriately advocate policy positions and values: Choices among options inevitably require the weighing of different values and tradeoffs. Although a researcher usually has personal opinions about which tradeoff is the "best," the personal values that drive that opinion are not "science". Damage to the credibility of the researcher, and to the research institution, is likely if the researcher advocates value-laden policy positions.

Not all scientists have the expertise to effectively engage in the policy process: Few scientists have the skills and temperament to work effectively at this interface. Being a capable researcher is not enough. Synthesizing the relevant science for decision-making is crucial. Science usually involves long-term testing of hypotheses whereas issues for policy or management decisions are often short-term and perceived as urgent. Scientists are obligated to do their best to understand and communicate their own biases and conflicts and to try to explain them (FROSCH 2001). Not all scientists need to have these skills, but too few seem to have them now.

Too few mechanisms and appropriately trained personnel exist to accomplish the timely transfer of new scientific knowledge: The current mechanisms for technology transfer are inadequate. Resource managers complain about the inadequacies of the research and development program's technology transfer. Synthesis and integration teams have been successfully used in the past, e.g. the National Acid Precipitation Assessment Program (PETERSON and SHRINER 2003). However, they also frequently resisted because of costs and perceived threats by scientists to their ability to synthesize their own work. Scientists, in turn, complain about the failure of resource managers and their professional staffs to assimilate and consider the latest research results in their decisions. Close collaboration among scientists, professional staff, and decision-makers is effective at transferring new science information to those involved, but dispersion of the new knowledge beyond those few is spotty.

> *"Developing reasonable solutions is very difficult in part because the method of knowledge generation and its delivery is in a period of uncertainty and flux …"* World Bank (1999).

Decision-makers and the public do not always consider or understand the scientific information available: Understanding is the key to the effective use of scientific information. Proper use of the science information requires full revelation of all consequences and risks of alternatives and decisions. It also requires a consideration of all scientific information, not just selected portions, before a decision is made. The increased disclosure could lead to increased public scrutiny and debate at various points in the decision process. This debate and openness are essential to achieving a science-based decision and maintaining the credibility of the science, especially given the increasing complexity of the decision issues and the attendant science information.

> *"The public does not understand a great deal of science and what cannot be understood is generally distrusted"* BLACKBURN (1994).

5 Communicating science findings and enhancing their application

The scale, scope, and complexity of natural resource and environmental issues have dramatically increased, yet the urgency to solve these issues often requires immediate information that spans disciplinary boundaries, synthesizes material from a variety of sources, draws inferences, and identifies levels of confidence. Choosing from available information and distilling the essential elements to identify potential implications for land and resource management can be overwhelming. The generation of new scientific knowledge is necessary but not sufficient for relevance without the communication and application of science findings. Moreover, there is oftentimes a science-policy lag as evidenced by the length of time required for a given scientific finding to assimilate into resource decision-making. In part, the lag can be attributed to the rate of information dissemination (BRADSHAW and BORCHERS 2000). The gap may be shortened through the development of new ways to interact with policy and decision-makers to optimize the diffusion of scientific information.

Responding to emerging issues: Critical issues emerge for which decisions will be made before long-term scientific studies can be completed. Relevant research findings, may, however, exist and have yet to be brought together and directed at the emerging issue. Clarifying such issues from a scientific perspective and determining how current scientific information can be made useful to policymakers is crucial. Scientific information needs to be synthesized and integrated to bring focus on the issue. Findings have to be packaged and delivered in ways that facilitate their use in decision-making, including public dialogue and other processes used by the decision-makers. This approach to informing decisions has the potential to reduce conflict by bringing attention to information about options and consequences rather than the advocacy of particular positions. These efforts can help clarify the character and form of the issue.

Bridging the gap between information generation and its use: Successful delivery of science means that policy and decision-makers receive tools and information that are understandable and readily meet their needs. Traditional venues of technology transfer often do not completely address the requirements of land managers, policy makers and resource specialists, who are increasingly confronted with a complex array of science information that may be difficult to interpret. To enhance the application of science to land management decisions and policies, science organizations need to place increased emphasis on developing conduits for relevant science to readily inform decision processes, by paying special attention to managers' information needs (including content, form and timing), appropriate and efficient avenues of delivery, and mechanisms (institutional linkages or processes) that promote collaboration between scientists and managers. Communication is more than just publication. Communication includes workshops, symposia, field trips, prototypes, demonstrations, working models, and site visits, as well as the appropriate use of electronic media and videos.

6 U.S. Pacific Northwest examples: dealing with information overload

Large-scale planning involves a variety of considerations and a number of issues. From the perspective of land managers, the Northwest Forest Plan (NWFP) considerably increased the amount of contact with the research community and probably created expectations for more extensive and rapid transfer of new knowledge (FEMAT 1993). At the same time, the sheer volume of new science information, some of which may appear conflicting, or may change as understanding evolves, has the potential to occasionally overwhelm and confuse the recipients. In spite of the difficulties, application of new information is occurring widely on the ground in several arenas, including disturbance and fire ecology, alternative silviculture techniques, large woody debris management, conservation of aquatic resources, and adaptive management processes. On the other hand, there are areas where research was identified as lacking or not available in usable forms (DIAZ and HAYNES 2002).

Building close relations between managers and scientists is a particularly effective tool for transferring new information to the ground (DIAZ and HAYNES 2002). Joint participation in project design, including problem framing, is critical to later acceptance of and interest in science findings. Once solid relationships and networks are in place, the value of publications and other materials in transferring knowledge will be improved.

Some institutional restructuring of research has been spurred by the effect of the NWFP because of the nature of information needed to support land management. For example, greater attention is being paid to the speedy delivery of management- and policy-relevant science products, and managers and scientists are interacting collaboratively much more than before. Part of the legacy of the NWFP is a strong need for collaborative learning – a multiway learning process in which scientists work with managers and stakeholders to both share and gain information about natural processes and local values and use, and to jointly frame solutions to public land use problems.

The different cultures and training of the research and management branches present serious challenges given the differences in time-scales between long-term research and short-term policy- and decision-making needs (DIAZ and HAYNES 2002). The greater demand for scientists to consult with field managers on project design and implementation has created time and workload demands that conflict with accomplishing fundamental research. The management and planning questions emerging from implementation of the NWFP are creating a greater need for science that weaves together the ecological, social, and economic dimensions of land management policy and practices. This change is leading to discussions within the science community about scale, multiple land ownerships, and how to achieve integration among science disciplines. Early steps have included the development of conceptual models of system components that show how parts interrelate, and the expansion of empirical and analytical efforts that explore multifunctional relations.

7 U.S. Pacific northwest examples: conceptual model for generating information for science-based decision-making

The temperate rain forests of the Douglas-fir region and southeast Alaska contain the highest quality wood-producing lands in the United States. They are among the most productive forests in the world (FRANKLIN 1988; FRANKLIN and DYRNESS 1973). These forests also have extremely high value for scenery and recreation, watershed protection, and fish and wildlife habitat (EVEREST *et al.* 1997). During the past decade, conflicts among demands for these values have intensified. Some sectors of our growing population have become highly polarized on forest management issues and distrustful of private and governmental institutions. Associated concerns about forest health, legal challenges, and uncertainty about future constraints on managed forestlands create additional complexity. A quest for solutions has become more difficult because society's resource problems and our agreements or disagreements on how best to manage those resources is a process that has become increasingly value laden. Consequently, finding compatibility among commodities and social and cultural values and articulating that compatibility in precise language are very demanding and necessarily challenging (PETERSON and MONSERUD 2002).

The challenge then is how to frame the discussion in a way that more clearly defines what the research role might be and what science is needed for decision-making. More specifically, what are the priority values that could be derived from various management actions and where can research contribute? The management of forestland is ultimately determined by societal values, which are interpreted by various institutions and then implemented as policies and goals. These policies and goals largely condition and limit the set of management actions that are technically feasible, resulting in a limited subset that are acceptable and allowable. Although the general public might have little knowledge of land management, they have strong expectations for values and uses of forestland, especially public land. Furthermore, their social attitudes and beliefs and values do provide direction for managers, albeit indirectly. These changing societal values are major drivers behind the new applied ecological and silvicultural experiments that have been implemented in the past decade. Examples of such experiments were presented at the IUFRO workshop "Applied large scale experiments" in Davos, in August 2003.

A conceptual framework was developed by Peterson and Monserud (2002) that allows the development of research problems and components while facilitating communication among people interested in a variety of values. This concept provides the basis for management decisions that are science-based. The effort focused on an outcome-based approach to the forest management problem of **wood** production jointly with other values: **wildlife** habitat and populations; **aquatic** resources; **biodiversity** measures as indicators of ecosystem health; **social** acceptance; and **economic** viability, including risks and consequences. To be successful, the research is, of necessity, directed at understanding processes or describing the state of the forest system.

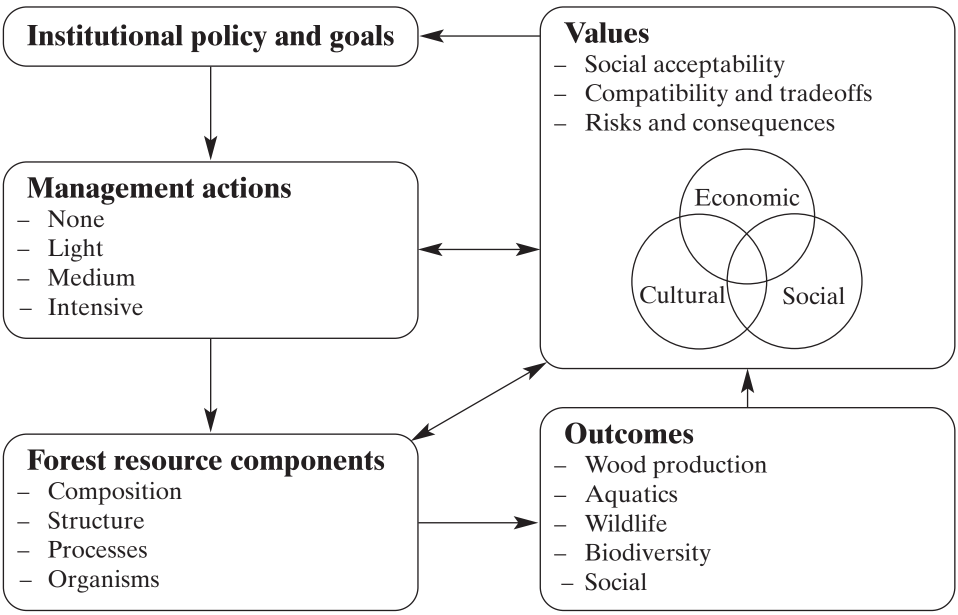

Fig. 1. Conceptual model showing interactions among forest resource components, societal values, institutions, management, and outcomes (from Peterson and Monserud 2002).

Figure 1 illustrates the basic interactions that help define the research context: social values influence institutional policy, which in turn affects managerial decisions and actions, resulting in a mix of outcomes. Those decisions and proposed actions are evaluated – often challenged – by society prior to being implemented, as a normal part of the planning process. Note that social concerns are not just at the top of this cycle in constructing policy and goals, but are also prominent in evaluating management actions that affect water quality, biodiversity, economic dimensions, and so forth. Once management takes action, the success of that action will depend to a large extent on whether the desired mix of outcomes is acceptable. The process is complicated by the fact that many of the values are realized in different areas and over varying lengths of time after the management action. This also complicates the task of gathering research information amenable to socioeconomic evaluation of risks and consequences (PETERSON and MONSERUD 2002). In this model, the mix of values feeds back into shaping institutional policy, and the process continues. This is a continuous feedback system that can adjust to changing needs and beliefs in an adaptive and iterative fashion. In order to produce desired outcomes as a result of management actions, we need to identify the biophysical functional components of the forest resource in terms that scientists can study and provide the information needed for science-based decision-making: structure, composition, organisms, functions, and processes, including natural disturbances. A study of the components will result in the necessary information to describe just how management actions influence the forest resource (vegetation, fish and wildlife, streams and hydrology, natural disturbances, and soil) to produce a desired mix of outcomes for society. The flow of information through this process illustrates the points where science can contribute to the decision-making process. Science is thus both a contributor to the process and a user of information and insights gained by management actions. Although socioeconomic research also could be viewed in this "resource impacts" box by including humans in the forest, it is found in the "values and outcomes" boxes.

8 Conclusions

Forest management can and should be science-based. The scope of topics that require increased consideration of science information is broad. Science should be considered in (1) assessing the trends and conditions of the resource and associated human systems, (2) making individual land management decisions, and (3) designing and implementing of adaptive management and monitoring systems.

There is no obvious right or wrong way to integrate science into the decision-making process but there are many points of view regarding the value as well as the problems associated with integrating scientific information into the policy and decision-making process. The differences between the development of scientific knowledge and its consideration need to be recognized. In science, the following of a relatively formal process is the norm leading to the acceptance of that information within the scientific community. However, the acceptance of scientific results by policy-makers, decision-makers and the public may differ markedly and be heavily influenced by personal perceptions and values.

The last two decades have witnessed a dramatic shift in how the public wants forest land to be managed. Yet, public values and attitudes regarding goods and services desired from the forest are often in conflict. Finding a balance and dealing with the trade-offs is often the key to effective forest management. In response, forest research and development has added new integrative and large-scale experiments that can better evaluate joint outcomes and improve policy and management decision-making. These large-scale experiments help in adapting management actions to achieve desired outcomes by providing information that integrates across disciplines in a real-time scenario.

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