Scientists in Wonderland

Experiences in development of forest policy

Jerry F. Franklin

Scientists have assumed a central role in the development, evaluation, and implementation of public policies regarding natural resources and the environment. This role is largely a consequence of the environmental legislation of the 1960s and 1970s—laws such as the National Environmental Policy Act, the National Forest Management Act, and the Endangered Species Act. These laws have spawned fundamental changes in the philosophies and approaches of agencies managing natural resources on federal lands. Many of the changes have come as a result of extensive litigation.

Because scientific issues are central to much of the direction provided in environmental laws, science and scientists have, not surprisingly, assumed an increasingly important role in attempts to resolve conflicts. Traditionally, agencies have been the primary sources and interpreters of science. For example, the US Forest Service (USFS) provided scientific information relevant to the national forests. However, over the last 20 years, federal agencies have increasingly lost credibility as objective scientific sources. Consequently, judges, legislators, and other decision makers have increasingly sought the direct involvement of scientists as independent sources of scientific information and judgments and, in some cases, as creators of science-based management plans or policy alternatives.

Forest issues in western North America have provided unusual opportunities for direct involvement of scientists

Forest issues in western North America have provided (and are continuing to provide) unusual opportunities for the direct involvement of scientists in policy. One example, on the federal timberlands administered by USFS and the Bureau of Land Management, is the conflict between timber harvest, on the one hand, and provisions for northern spotted owls, old-growth ecosystems, and anadromous fish, on the other. The legal, social, and some aspects of the scientific history of this conflict have been reviewed by Yaffee (1994).

This northwestern-forest issue has been addressed in a series of significant scientific assessments led by scientists (Figure 1). Frustrated with nearly complete gridlock in management of the national forests, Dale Robertson, who was then chief of the National Forest Service, chartered the first of the independent scientific assessments in 1989. Wildlife researcher Jack Ward Thomas was asked to organize an independent scientific committee—called the Interagency Scientific Committee for Recovery of the Northern Spotted Owl—to create a "credible scientific plan" for management of the northern spotted owl. For various reasons, primarily political (impacts on timber harvest were too high), the plan that resulted (Thomas et al. 1990) was never formally adopted. Several other assessments followed: the 1991 Scientific Panel on Late-Successional Forest Ecosystems (labeled the "Gang of Four," because it was composed of four principal scientists), which was chartered by two congressional committees; the Scientific Analysis Team (SAT 1993), a group put together to respond to a series of scientific questions raised by Judge William Dwyer; and the Forest Ecosystem Management Assessment Team (FEMAT 1993) chartered by President Clinton. The last-named effort produced an alternative plan that was recently accepted by the courts as scientifically credible and adopted by President Clinton.

The use of scientists to construct science-based policy alternatives has spread to other parts of western North America. In the Sierra Nevada Range of California, an agency-based science effort has provided interim management direction for the California spotted owl (Verner et al. 1992), and in a program called the Sierra Nevada Ecosystem Project (SNEP), an independent, academic team is currently assessing conditions and developing policy alternatives (SNEP 1994) under both a congressional and USFS charter. The US Congress also chartered an independent scientific review of Indian forest lands and management—the Indian Forest Management Assessment Team (IFMAT 1993). In British Columbia, Premier Michael Harcourt has established an independent group called the Scientific Panel for Sustainable Forest Practices in Clayoquot Sound (1994) to assess the adequacy of current forest practices. And other studies by scientists have been completed or are underway.

These studies are challenging experiences for the natural scientists who participate, because traditionally scientists are not educated in technical aspects of policy development, the practice of politics, and interactions with other professional and social groups. Consequently, these studies have provided the scientists with valuable lessons in how scientific knowledge is effectively used in developing natural resource policy. In this article, I identify some lessons that I consider important based upon my experiences as a participant in several scientific analyses—the Gang of Four, FEMAT, SNEP, IFMAT, and the Clayoquot panel.

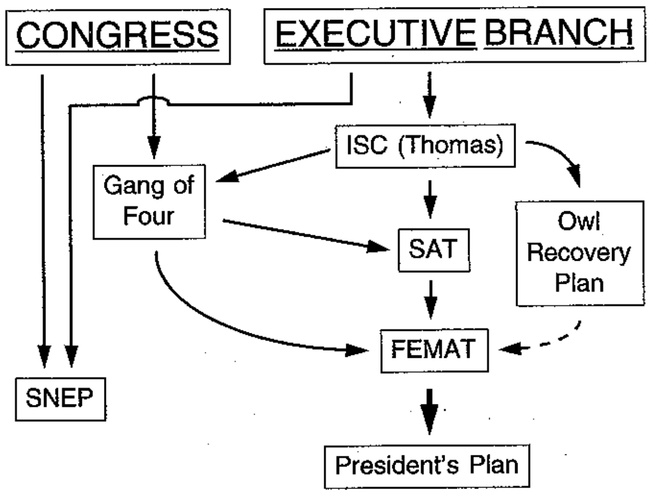


Figure 1. The "genealogy" of several major forest policy analyses conducted for federal timberlands in western North America. These analyses built on concepts developed in preceding efforts as shown by the arrows. ISC = Interagency Scientific Committee to Address the Conservation of the Northern Spotted Owl (Thomas et al. 1990); Gang of Four = Scientific Committee on Late Successional Forest Ecosystems (Johnson et al. 1991); SAT = Scientific Analysis Team (1993); Owl Recovery Plan = Northern Spotted Owl Recovery Team (1992); FEMAT = Forest Ecosystem Management Assessment Team (1993); and SNEP = Sierra Nevada Ecosystem Project (1994).

Creating and evaluating multiple alternatives

Creating and evaluating a range of alternatives can be an effective approach in applying scientific information in policy development. Most scientific and technical personnel are trained to solve problems rather than to develop and evaluate alternatives. Sometimes scientists are directed to provide a solution or a plan, as in the case of the Interagency Committee (Thomas et al. 1990). Generally the possibilities are multiple rather than singular. Sometimes scientists are instructed to describe alternatives that may provide for a range of outcomes—such as varying probabilities of achieving some objective—or for alternative ways of achieving similar outcomes.

The contrast between having a single solution and having multiple alternative plans is illustrated by comparing the Interagency Scientific Committee (Thomas et al. 1990) with the Gang of Four (Johnson et al. 1991). As requested, the Interagency Committee developed a plan for protection of the northern spotted owl, much of which was later adopted in the recovery plan (Northern Spotted Owl Recovery Team 1992).

In contrast, the congressional direction to the Gang of Four encouraged consideration of multiple alternatives. Fourteen major alternatives were evaluated. They varied in their emphasis, which ranged from timber production to protection and restoration of late-successional forest conditions. In addition, variations in potential treatment of the unreserved forest lands (lands still available for timber harvest and typically referred to as matrix lands) produced 34 alternatives. Selected variables, such as the amount of land to be held in reserves, were systematically altered across the alternatives to facilitate analysis of the marginal costs-and-benefits obtained from each increment of change. Evaluations of alternatives emphasized the probability of achieving specific ecological objectives for the next 100 years and specific levels of timber harvest (Figure 2).

Like the Gang of Four, FEMAT followed the strategy of developing and evaluating multiple alternatives (Thomas 1994). Reserve area and distribution, riparian zones, width, allowed levels of management, and many other variables were changed among ten alternatives. However, the alternatives were not incremental (i.e., several variables were changed simultaneously), making marginal analyses difficult. Evaluation of social (including economic) and ecological consequences were much more comprehensive in FEMAT than in the Gang of Four analysis.

Development and evaluation of multiple alternatives allows decision makers—and everyone else—to see the range of possibilities and the probable consequences of each possibility. I have often heard the objection to this approach that decision makers, provided with multiple alternatives, are likely to choose the one that provides greatest economic benefits. My experience has been that the truly viable alternatives—alternatives that achieve legal goals and other societal objectives at acceptable levels of probability—tend to be obvious in such an analysis.

For example, a conservative congressman, then Representative Robert Smith of Oregon, viewing the projected outcomes for the Gang of Four alternatives immediately noted that Congress would not legislate anything below alternative 8 (see Figure 2)—because any alternative with ecological ratings that included a low probability of success in achieving the ecological goals was unacceptable. The critical point is that (regardless of his particular interest in the economic goals) the range of viable alternatives (the so-called decision space) was immediately apparent to him.

Perhaps most fundamental, in democratic societies decision makers are elected to make choices among alternatives. The policy choice is not the prerogative of scientists. By developing and evaluating alternatives, scientists can clearly and objectively display the costs and benefits, based on the best available information, of different choices. If credible, such analyses can be powerful in holding decision makers accountable for their actions—such as by making it clear that there is no free lunch, that is, no choices without costs (Johnson et al. 1991).

Value of spatially explicit information

Spatially explicit information (e.g., maps and geographic-information-system data layers) is critical in development of meaningful policy alternatives. Many (if not most) of the first generation of plans for the national forests produced in the late 1970s and 1980s foundered in subsequent judicial challenges, in part, because outputs were based upon Forest Plan Model Simulator runs that were not spatially explicit. Plans projected specific permissable levels of timber harvest based upon acres available and tree growth rates. But when resource managers began to identify areas for cutting, numerous spatial constraints made it impossible to find enough acres available for harvest to meet the projected cut levels. Examples of spatial constraints are the cumulative effects of harvest on hydrologic regimes and limits (so-called greenup requirements) on cutting of areas adjacent to old clear-cuts until the forest on the previously cut area had achieved a specified miminal height and cover. In effect, it is not enough to know that there are a certain number of acres of land in a given condition or allocated to a particular use; it is also necessary to know where those acres are, the size and shape of patches, and the condition and allocation of the adjacent acres.

In the Pacific Northwest, spatially explicit data have been critical in both developing and evaluating credible alternatives and in presenting the results to scientific peers, decision makers, and the public. Geographic information systems have been valuable in manipulating and presenting these databases and are increasingly likely to be a vehicle for communicating accurate representations of alternatives (Franklin 1994).

Use of resource specialists

Resource specialists can be one of the most valuable resources for scientific policy analyses. Today most agencies engaged in managing natural resources (and many involved in enforcing environmental laws) have resource specialists representing a broad range of disciplines—including physical sciences (e.g., geologists and hydrologists) and biological sciences (e.g., silviculturists and zoologists). Many of these staff specialists have spent years, even lifetimes, working in specific geographic regions. Their on-the-ground knowledge of, for example, forests, wildlife, and fisheries is typically unparalleled. Accessing this knowledge to assess conditions and evaluate alternative management strategies can greatly strengthen a scientific policy assessment.

The resource specialists are often overlooked by scientific teams chartered to conduct policy analyses. Traditional resources—such as aerial photographs and other forms of remotely sensed data, maps, academic specialists, and sample-based datasets—are often more obvious and easier to access. While acknowledging resource specialists' familiarity with the resource, scientists sometimes question the technical competence and, more often, the objectivity of agency-based personnel.

It is critical that a scientific team identify the key resource specialists, provide adequate direction and quality control, and empower the specialists to share their knowledge. Key elements of this empowerment process include: clear direction as to overall objectives of the exercise and the information and interpretation that are sought and provision of a safe working environment where specialists can provide accurate information without fear of retribution by a supervisor or an agency.

More than 100 agency resource specialists were involved in the Gang of Four and FEMAT analyses, and some of them plus others are currently participating in the SNEP analysis for the Sierra Nevada. They have participated primarily in interpreting various imagery and databases to produce maps and new databases on forest and wildlife habitat conditions, such as the quality of late-successional forest habitat. Their on-the-ground knowledge has proven critical to the success and credibility of these exercises. As part of the empowerment process, the activities of these specialists were concentrated at a location isolated from their normal work environment and excluded line managers and supervisory personnel. In my experience, these specialists consistently provided accurate and objective information that was otherwise unavailable. It is tragic that resource management agencies have failed to harness fully the knowledge and creativity of their resource specialists and to display it to decision makers and the public.

The concept of flagship species is dangerous

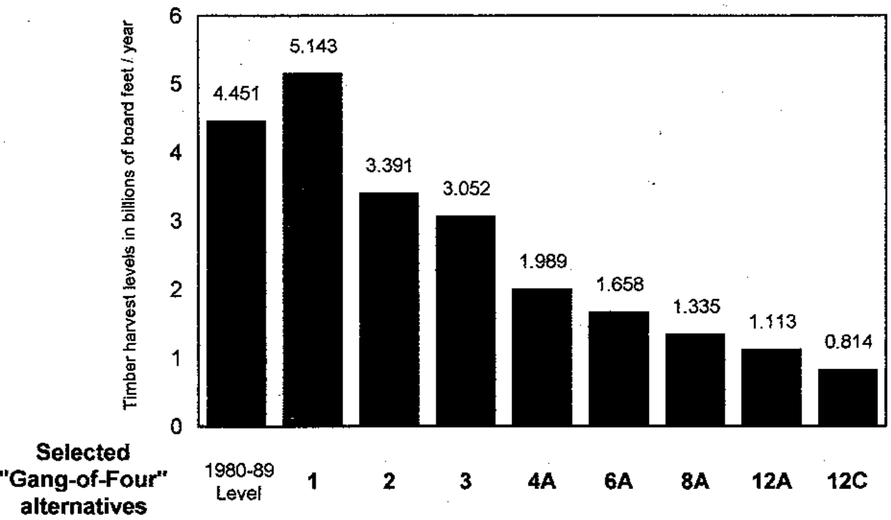
Much has been (and much more is likely to be) written about the relative merits of conservation strategies based upon individual species versus those based upon ecosystems. It has been argued that, even though species-based approaches have limitations, high-profile species with major habitat requirements (e.g., northern spotted owls or grizzly bears) can function as so-called flagships or surrogates for major ecosystems (see, for example, Wilcove 1993); for example, in providing for the habitat requirements for northern spotted owls one is likely to simultaneously provide for old-growth forest ecosystems and other related organisms.

Societal experiences in policy analysis in the Pacific Northwest suggests that such assumptions are dangerous. In the genealogy of the northwestern policy analyses (Figure 1), activities began with a species-based effort (Thomas et al. 1990) and progressed to exercises

(FEMAT 1993, Johnson et al. 1991) that included alternatives that took more ecosystem-based approaches (i.e., concerns with old-growth forest and aquatic ecosystems rather than simply with northern spotted owls or marbled murrelets). It was not possible to move to entirely ecosystem-based approaches because many of the laws (the National Forest Management Act and the Endangered Species Act) relate to specific species. Nevertheless, some useful comparisons are possible.

The Interagency Committee (Thomas et al. 1990) developed, as requested, a plan specific to the northern spotted owl. The plan recommended a heroic shift in strategy from the protection of isolated individual owl territories (known as owl circles) to protection of large reserves for multiple owl pairs spaced at regular geographic intervals. It also broke important ground in recommending that federal forest areas between reserves (the matrix) be managed so as to improve the potential for successful dispersal of owls. Developing a plan that also protected high-quality, old-growth forests was not a part of the committee's charter except as necessary to provide for viable populations of northern spotted owls. In fact, the committee designed its reserve system of habitat conservation areas so as to achieve the plan's objective (viable owl populations) while minimizing impacts on timber harvest levels.

Subsequent analyses (FEMAT 1993, Johnson et al. 1991) showed that, even though of extraordinary magnitude, the system of habitat conservation areas developed for the northern spotted owl did not do a good job of protecting old-growth forest ecosystems or habitat for the anadromous fisheries (Figure 2). These results were not surprising—habitat conservation areas were not designed to achieve these objectives. Specific examples of how bad can be the fit between owl-based and ecosystem-based plans are illustrative: In the Umpqua National Forest, Oregon, the areas proposed as owl habitat conservation areas (Northern Spotted Owl Recovery Team 1992, Thomas et al. 1990) incorporated less than 50% of the most



Probability of retention for a century or longer

	1980-89 Level	1	2	3	4A	6A	8A	12A	12C
Functional Old-Growth Network	n/a	VL	VL	L	ML	M	M	MH	VH
Viab Spotted Owl Population	n/a	VL	L	ML	H	H	H	VH	VH
Marbled Murr Nesting Hab	n/a	VL	L	L	ML	M	M	MH	H
Other Old-Growth Species	n/a	VL	VL	L	ML	M	MH	H	VH
Sensitive Fish Stocks	n/a	VL	VL/L	VL/L	L	ML	MH	MH	VH

Figure 2. Timber harvest and probability of achieving various objectives under historic rates of timber harvest (1980–1989) and under eight selected alternatives from the "Gang of Four" (Johnson et al. 1991). Ratings under probability of retention are VL = very low, L= low, ML = medium low, M = medium, H = high, and VH = very high (estimated 50% probability of achieving goal).

significant late-successional/old-growth forest (also called LS/OG1) identified by the Gang of Four (Johnson et al. 1991). A similar lack-of-fit existed between habitat conservation areas and high-quality, late-successional forest areas in several other Cascade Range national forests. As another example, in FEMAT, resource specialists focusing on marbled murrelets preferred to use high-quality, old-growth forest areas (identified in Johnson et al. 1991) as the basis for murrelet reserves rather than the owl-oriented habitat conservation areas.

SAT (1993) and FEMAT (1993) demonstrated that it is impossible to use a species-by-species approach in developing a comprehensive plan. Regional plans of this type potentially involve thousands of species, many unknown; even among the known species, there are hundreds with conflicting and contrasting habitat requirements. These exercises provide clear evidence of the absolute necessity of devising habitat-based, multispecies approaches.

Limitations of scientists

The exercises in western North America have highlighted several important limitations on scientists as creators and evaluators of policy. Scientists tend to think in terms of a single solution to a problem, scientists do not like to base proposals on incomplete information, and faced with incomplete information, scientists are usually conservative. In addition, scientists lack training or experience in policy analysis, have difficulties in communication, and often suffer from hubris.

As Thomas has said on numerous occasions, "science-based policy analyses are not science."[1] They involve the synthesis and application of (one hopes) the best available scientifically based information. However, decisions always have to be made with incomplete and, sometimes, grossly inadequate knowledge. Hence, development and evaluation of policy alternatives requires scientists to extrapolate far beyond existing databases and theoretical constructs. Scientists who are uncomfortable with projecting beyond the known had best not apply. But if scientists fail to make the judgments and do the extrapolations, someone else, perhaps someone much less qualified, is prepared to do so. Further, scientists need to understand that policy analysis, however logical or systematic, is not a scientific process, so they must not expect that it will follow traditional scientific methods or be judged primarily by scientific peers. In policy analyses, what is called truth is not singular. It probably is not in ecology either, null hypotheses not withstanding.

Expert systems—such as creation of scientific panels—provide one valuable way for developing a scientific consensus based on current (and typically inadequate) information. Such systems were used by Gang of Four and FEMAT to provide probabilistic judgments about outcomes under various policy alternatives.

Natural scientists often lack training in policy analysis and in relevant communication skills. Few have had any academic exposure to the objectives and mechanics of policy formulation and analysis. The concepts of modular alternatives and marginal analyses are concepts that I learned as I served on policy committees.

Natural scientists often lack communication skills relevant to policy development. The observation that many scientists fail to communicate—or to listen well—is not new. The communication problem can be major in interdisciplinary exercises. Policy analysis teams typically include economists, other social scientists, and various nonscientific participants. The Clayoquot Sound panel incorporates four Native American leaders, one as cochair of the panel. Communicating in plain language, free of disciplinary jargon, is a critical skill. The ability to listen is even more critical, because without it, one cannot hope to understand and incorporate different points of view.

Scientists are often not well adapted to the time and space limits of policy analyses. Analysts must scale their activities to the resources and time available. The large spatial scales of a problem often limit the amount of detail that can be incorporated in an analysis; scientists trained in a reductionist mode may find it difficult to leave behind this detail.

Hubris is, perhaps, the most serious limitation of the scientist involved in policy analysis. Policy exercises clarify, very quickly, the serious limitations of our knowledge and understanding. In developing strategies for the forests on the Pacific Coast, for example, the foci and theories of traditional conservation biology were found to have limited application. Many biologists have biases against ecosystems that incorporate human activities and favor conservation strategies focusing on strict reserves and equating connectivity with corridors. Traditional conservation biology has been strongly oriented to terrestrial habitats and vertebrates.

Why participate in policy analysis?

Despite many difficulties, there are both professional and personal reasons for participating in science-based policy analyses. Such activities can be valuable professionally. They provide real-world experiences in the application of science, experience that brings a freshness and relevance to teaching programs. In terms of research, policy analyses are identifying many of the critical topics or hypotheses in ecological science. Examples include increased interest taken by ecologists in landscape connectivity (not just corridors) and in the role of unreserved lands in maintaining biological diversity.

The personal satisfactions that can come from participating in such activities should be obvious. Prominent is the satisfaction of working to ensure that decisions are based on the best science available and that decision makers (and society) understand clearly the difficult tradeoffs. All those involved in policy decisions need to be reminded regularly that there is no free lunch.

[1]J.W. Thomas, 1991, personal communication. US Forest Service, La Grande, OR.

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