



United States
Department of
Agriculture

Forest Service

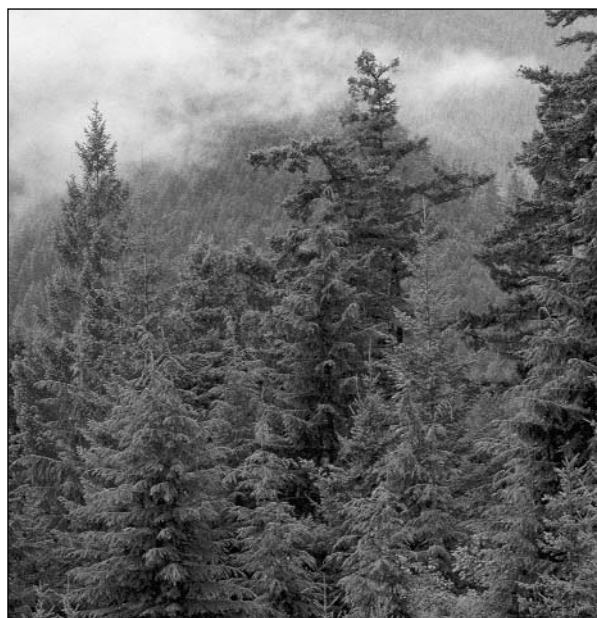
Pacific Northwest
Research Station

Station Misc.
April 2002



Achieving Science-Based National Forest Management Decisions While Maintaining the Capability of the Research and Development Program

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Abstract

Mills, Thomas, J.; Smythe, Richard V.; Diaz-Soltero, Hilda. 2002. Achieving science-based national forest management decisions while maintaining the capability of the research and development program. Washington, DC: U.S. Department of Agriculture, Forest Service. 20 p.

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. Two issues must be addressed simultaneously. First, how can the Forest Service ensure that full use of science information is the norm in all national forest management decisions? Second, how can Forest Service Research and Development be a major science provider for national forest decisions without damaging the credibility and research capabilities of the research and development program? A vision for science-based decisionmaking is articulated, and barriers to achieving that vision are discussed. Vital actions are proposed for overcoming the barriers and achieving the vision of science-based decisionmaking while maintaining the capability of the research and development program. These capabilities include providing adequate funding and staffing for the National Forest System and Forest Service Research and Development, new approaches for managing scientific staff, and new ways to transfer science information.

Keywords: Scientist role, land management, research organizations.

Foreword

The mission of the USDA, Forest Service is to sustain the health, diversity, and productivity of the Nation's forests and grasslands to meet the needs of present and future generations. A major focus of that mission is management of the national forests and national grasslands. A less direct but also important role is assisting in the stewardship of nonfederal forest lands and international forestry issues. The provision of scientific knowledge through its research and development program is another aspect of the Forest Service mission. Forest Service Research and Development provides scientific knowledge that enhances our fundamental understanding of renewable natural resources and undergirds their sustainable management on all lands, private as well as public.

This report builds on the suggestions in the two Rensselaerville Roundtables (USDA Forest Service 1995, 1997) about science-management collaboration. It goes further, however, in that it identifies the steps necessary to institutionalize collaboration between agency land managers and research scientists at all levels while still retaining a vital research and development program that continues to add to the body of scientific knowledge related to forests and rangelands.

A handwritten signature in black ink, reading "Dale N. Bosworth". The signature is fluid and cursive, with a prominent "D" and "B".

Dale N. Bosworth
Chief
USDA Forest Service

Introduction¹

The USDA Forest Service has a proud heritage of professional leadership among conservation agencies. This heritage is in part because of the agency's unique combination of program responsibilities. The Forest Service both manages the largest acreage of public forest lands in the United States (National Forest System) and also administers the world's largest forestry research program (Forest Research and Development). The research program is an independent organization within the agency. This independence maintains an appropriate organizational distance between the two programs that is necessary for credible research and credible science contributions to contentious policy decisions. This unique composition gives the Forest Service significant opportunities to assist in the evolving public debate about natural resource management.

For the past two decades, the Forest Service has been embroiled in a public debate over contentious issues about national forest management. The issues are diverse and include management of old growth and persistence of the northern spotted owl, the viability of pacific salmon stocks, and management of fire-dependent ecosystems and roadless areas. Forest Service Research and Development has increasingly contributed to the resolution of these contentious issues by providing the science foundation for the associated resource management decisions.

Although scientific information and knowledge are only one consideration in natural resource decisions, credible science is increasingly necessary to gain public support for proposed actions. 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 decisionmaking on topics such as health care and environmental protection. It has been frequently recognized that science-based national forest decisions should be the norm and that Forest Service Research and Development can play a role in making those decisions (e.g., Committee of Scientists 1999; Johnson et al. 1999; Mills et al. 1998; National Academy of Public Administration 1999; USDA Forest Service 1995, 1997a, 1997b).

Full consideration of the relevant and available scientific information provides understanding of the natural and human systems. A science foundation can help people with diverse perspectives come together and understand a system in which they are all interested. Science information improves the ability to estimate consequences and risks of decision alternatives. Science insights may occasionally lead to new management alternatives that increase compatibility among people holding diverse values for the land. Moreover, the full and open consideration of available science information, especially when brought to the decision process by someone who is recognized as both expert and objective, adds credibility to the decision and the decision process.

¹ This report was prepared at the request of Robert Lewis, Deputy Chief for Research and Development, and Mike Dombeck, Chief, USDA Forest Service. This report has benefited materially from several reviews, especially the Interregional Ecosystem Management Coordination Group, but the views herein are the sole responsibility of the authors.

The Forest Service has considerable experience with the interface between science and management decisions.² Scientists in universities and in other federal and state agencies and resource professionals in the National Forest System have played a role in providing science information for decisionmaking. The primary science provider for decisions on high-profile and contentious issues, however, has been research scientists from the research and development program of the Forest Service. The research and development program has been called on with increasing frequency and insistence on its being the primary provider of the science foundation for National Forest System decisions. Another potential mechanism for review of scientific information would be a science advisory committee. Because of time constraints required to provide information on contentious issues, however, such a committee would not likely function well as the primary provider of science information to the decision.

Thus, Forest Service Research and Development will likely continue to be a primary provider of science information for national forest management decisions, and on an even greater scale as the demand for science-based decisions increases. This added responsibility, however, must be successfully dovetailed with the existing responsibility of conducting research demanded by a broad array of customers. Forest Service Research and Development is valued for its contribution of science information relevant to decisions by other landowners, such as state agencies and private forest landowners. Sacrificing continued research or other research clients to take on the expanded role in providing science-based information on national forests issues has unacceptable consequences.

Nonetheless, successful involvement of Forest Service Research and Development at the science-policy interface provides valuable benefits to research as well as to National Forest System land management decisions. Forest Service Research and Development scientists gain insights into the decisionmaking process and the form of information most helpful to decisionmakers. After such interface, researchers are better able to formulate questions for study that lead to research that is often more relevant and readily applied to resource management issues than it was when there was not this interaction.

Although collaboration exists between individual agency managers and Forest Service Research and Development scientists to achieve a science-management interface, it is yet to be broadly institutionalized and is driven by individual initiatives rather than by typical organizational behavior. Examples of institutionalized collaboration that demonstrate approaches for guiding such efforts are few. A rare example is the Interagency Research and Monitoring Committee established to assist in the adaptive management of the Northwest Forest Plan. Similarly, current funding, staffing, organizational structure, and reward systems are not sufficient to ensure

² The agency has experience with many decisions about individual species, such as the recovery plan and management of the red-cockaded woodpecker (*picoides borealis*). These issues, particularly the more recent examples, have been broader ecosystem and often landscape-scale efforts, such as the interior Columbia River basin assessment, the Sierra-Nevada Assessment, Southern Appalachian Assessment, the Northwest Forest Plan, and the Tongass National Forest Plan (Clark et al. 1998).

Figure 1—Two issues need simultaneous attention.

- What is necessary to ensure science-based national forest management decisions are the agency norm?
- What is needed to protect the capability and credibility of the research and development program to advance the body of scientific knowledge and serve as a credible source of science information for decisionmaking?

an adequate level of science support for policy decisions while simultaneously sustaining a responsible research and development agenda. Past efforts have clearly demonstrated that the successful interface between science information and decisions on contentious issues is difficult and costly.

Two challenges exist. The first is to adequately provide and fully consider the relevant science in decisions about the management of the national forests and grasslands. This challenge is significant, though achievable if carefully addressed. A tempting short-run solution, and one that has been used in several contentious decisions in the recent past, is to have the research and development assume the role of primary science provider for National Forest System decisions.

But therein lies the second challenge. Providing the relevant science for all National Forest System decisions is a substantial job relative to the size of Forest Service Research and Development staffing. If Forest Service Research and Development fills that role, it will pull a substantial number, and perhaps all, of the research and development scientists away from conducting research studies and instead focus them on providing science for decisionmaking on national forests and grasslands. That in turn will reduce the research activities, the very activities through which the scientists gain their specialized expertise, their scientific credibility, and their scientific information. Probably in the intermediate term, and certainly in the long term, that added responsibility would endanger the production of new scientific knowledge and the continued credibility of the research and development program unless the added responsibility is matched with increased funding, staffing, and management attention.

The Forest Service must enhance and institutionalize the routine consideration of the scientific foundation of policy decisions. Although we acknowledge difficulties and serious challenges, we are confident proactive steps can both improve the science basis of national forest decisions and protect the credibility and capability of Forest Service Research and Development. But definitive actions are needed and soon.

Issues

If the goal of science-based national forest decisions is to be achieved, two issues must be addressed simultaneously (fig. 1).

The first issue is how can the Forest Service ensure that the full use of science information is the norm in all national forest management decisions? Decisions about land management are increasingly contentious and complex. The public controversy about forest management, in particular the management of the multiple-use public lands, is greater than ever. Social values associated with public lands are diverse. Federal case law continues to evolve in its interpretations of the statutes and regulations governing national forest and grassland management. The march of science progressively expands the body of relevant scientific information. New technologies distribute this information to all interested parties with accelerating speed. In turn, land managers are nearly overwhelmed as they assimilate all relevant information and public values and document the consideration of these factors in their decisions.

Although science information does not direct any decisions, it is one set of vital information to consider before making a decision, especially on large or complex 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.

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.

The second issue is how can the Forest Service engage its research and development program as a major provider of the science foundation for national forest decisions without damaging the credibility and research capabilities of this program? Neither research scientists in Forest Service Research and Development nor professional staff³ in the National Forest System are now able to meet the challenges of the science-based decisionmaking issue.

The research and development program of the Forest Service provides considerable scientific information that enhances the understanding of both natural and human systems. That increased scientific understanding not only provides the basis for the evaluation of management alternatives but it affects the way the public and decision-makers view the options. The research and development program provides information that is used to predict the consequences and risks of management alternatives and can potentially provide information for developing management options that can increase the compatibility among the different values that people hold for land. Within its current mission, the research and development program strives to provide the best science on key issues that address critical needs beyond specific national forest concerns and are inclusive of issues relevant to other agencies and other lands.

³ The "professional staff" refers to professionals in the National Forest System organization at the national, regional, and forest level, such as the range, wildlife, fisheries, recreation, and forest management staffs. It also refers to staff in the State and Private Forestry organization at similar levels that focus on national forest management as well as the management of state and private forest land; e.g., Forest Health Protection and Aviation and Fire Management.

The solution to this second issue is not simply to shift among different priorities within the research and development program. The scale of the national forest decisionmaking job is enormous in relation to the size of the research and development program. A simple reallocation of program priorities would sacrifice the ongoing research program. The research and development program includes about 550 scientists nationwide, down from over 1,000 scientists two decades ago. And although the number of scientists is down, the value of the scientific information and the complexity of knowledge gained is quickly expanding. The current research and developments program would cease to be viable if it were responsible for providing all or even most of the science information for National Forest System management decisions. By contrast, there is considerably more professional staff with graduate degrees in the National Forest System than there is in Forest Service Research and Development. As of October 1999, about two-thirds (1,900) of the total Forest Service staff with graduate degrees is in the National Forest System. Most of those staff should be capable of synthesizing and utilizing the available science information relevant to a decision.

The current level of involvement of research and development with management decisions is already seriously undercutting the ability of Forest Service Research and Development to maintain its research program. For example, the interior Columbia basin scientific assessment, evaluation of management alternative consequences, and science consistency evaluation; the science assessments and science consistency evaluation for the Tongass National Forest plan revision; and the science assessments and evaluation of management alternative consequences for the Northwest Forest Plan alone absorbed a substantial portion of time of the 80 permanent full-time research scientists of the Forest Service's Pacific Northwest Research Station. Other assists to decisionmaking, such as to the development of Oregon's Forest Practices regulations, absorbed yet additional time of research and development scientists. Other large science efforts, especially when directly associated with decisions on contentious issues, absorb similarly large shares of the capabilities of the research and development program in other parts of the Nation.

These contentious decisionmaking efforts usually demand the involvement of the best and most mature of the already limited total number of scientists. The scientists involved are often engaged full-time for years providing science for a difficult decision. Sometimes the lead scientists of the efforts become so entangled in providing science to protracted decision processes that they never return to their research assignment.

Without increases in funding and staffing, the current substantial contribution of research and development to the scientific foundation for major management and policy decisions is unsustainable. Current involvement in decisionmaking is already "mining" the research accomplishments of the past without continuing to build the scientific discoveries on which the next generation of resource management decisions will be based, decisions not only about the management of the national forests but also of other lands. Three unacceptable consequences would quickly ensue.

The first consequence would be that other clients of research and development would no longer receive important research results. State resource agencies, private land-owners, elected officials, and policymakers, for example, would all cease to receive research products that they have found valuable and on which they depend. Examples include Forest Service research on tree improvement genetics, silvicultural systems, dynamics and management of insect and diseases, fire management, fish and wildlife habitat, and forest ecology. Some have already suggested that Forest Service Research and Development has deviated too far from its core mission and from providing research results to those other clients.⁴

The second consequence would be the erosion of the credibility of Forest Service Research and Development as a science provider. The ability of the research program and development to successfully provide the science for national forest decisions rests on the demonstrated ability of its research scientist to produce scientific results within an arena of open and rigorous peer review and critique. It also rests on their personal, professional credibility. The credibility of science information and the credibility of the science information provider derive their association with the broader scientific community, not from involvement in decision processes.

Scientific credibility has become key for acceptance of science information in decisions about the management of public lands. If Forest Service Research and Development no longer retained a vital program of independent research, its ability to credibly contribute the science foundation for decisions would erode. That in turn would erode the attributes that make the research and development program successful and desirable as a provider of science to national forest management decisions. Indeed, the research program was made separate from the forest management branch of the Forest Service decades ago for the purpose of ensuring the independence necessary for the credibility of agency research.

The third consequence would be a reduction in the credibility of the professional staff of the National Forest System. Focusing on the research and development scientists alone would imply that the National Forest System professional staff is neither capable of being nor credible to be a primary science information provider. The credibility and capability of the National Forest System professional staff to be science providers to the decision should be increased, not eroded.

If not handled appropriately, the long-term research capability, integrity, credibility, independence, and productivity of research and development will be sacrificed for the short-term enhancement of national forest management decisions (Mills et al. 1998). The intended outcome, that Forest Service Research and Development provide credible science for the science-based national forest decisions, would in turn be unsustainable.

⁴ U.S. Senate. [2000]. Department of the Interior and Related Agencies Appropriations Bill, 2001. Washington, DC.

Figure 2—The vision of science-based decisionmaking.

- Decisionmakers and the public fully appreciate the contributions of science to decisions about land management.
- Forest Service Research and Development research scientists and National Forest System professional staffs provide the science information needed for the decision.
- Policy-relevant science information is readily available and is presented in a manner that facilitates easy use.
- The available science information is fully used and considered by the decisionmaker.
- The consistency of major land management decisions with the available science information is evaluated.
- Science information is recognized as important but only as one of the pieces of information considered in a decision.

The two issues—achieving science-based national forest decisions and protecting the capabilities of the research and development program—are interlinked. Their solutions are mutually dependent. Solving one without solving the other will not provide a lasting solution. A simultaneous solution can improve the science foundation while protecting the credibility and capability of the research and development program.

**A Vision for
Science-Based
Decisionmaking**

Although the desirability of “science-based” decisions is recognized (e.g., Committee of Scientists 1999), clarity is lacking on what that means. Our vision of the prerequisites for science-based decisionmaking for the National Forest System focuses on 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. The following describes this vision realized (fig. 2).

Decisionmakers and the public appreciate the contributions of science to decisions about the management of the national forests and grasslands.

Understanding and applying relevant science helps land managers and publics evaluate the status of and risks to ecosystems, identify sustainable land management goals, 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 limits of our ability to predict the future, and ensure that the uncertainty of our knowledge is recognized. Broad acceptance of credible scientific information contributes to increased public consensus about the management of the national forests and grasslands.

Forest Service Research and Development research scientists and National Forest System professional staffs provide the science information needed for the decision. Forest Service Research and Development scientists and National Forest System professional staffs work to synthesize and apply science information to decisionmaking. University scientists and scientists in other federal and state agencies continue to be an important source of science information relevant to Forest Service decisions, but Forest Service personnel coordinate development and application of that science information.

Policy-relevant science information is readily available and is presented in a manner that facilitates easy use. The science information is synthesized into policy-relevant packages (e.g., Clark et al. 1998; FEMAT 1993; Iverson et al. 1996; 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 a way that is 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). This science information is subjected to the same standards of scientific quality assurance; i.e., independent peer review of written documents, as any other science findings (Mills et al. 1998).

The science information is documented and is readily accessible to all interested parties. Science findings summaries, briefings, and packages of science information in decision support systems provide meaningful access to knowledge. The science information is presented in a manner that is not only easily assimilated, but also hard to ignore.

The available science information is fully used and considered by the decisionmaker in making natural resource management decisions. The National Forest System professional staff and the decisionmaker are aware of the relevant science information. They understand the relations presented in the science documents. Decisionmakers and professional staff use that knowledge and understanding

to design management options and estimate the consequences of these options. The decisionmaker reveals the consequences of the final decision, and those consequences are consistent with the relations revealed in the science information.

The consistency of major land management decisions with the available science information is evaluated and documented. The decisionmaker ensures that the decision is consistent with science. The decisionmaker accomplishes this by evaluating 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).⁵ This includes all scientific subjects, social and economic as well as physical and biological. The final science consistency document is developed iteratively as the decision evolves to provide the decisionmaker with draft consistency information before reaching a final decision.

Such an evaluation demonstrates a commitment by the decisionmakers to fully consider science information in reaching a decision and a commitment to revealing the projected consequences of the decision. It also demonstrates a commitment by scientists to avoid advocating any particular solution as if only one solution could be the outcome of the scientific information or that only one solution were consistent with the full and complete consideration of the science information about system function and consequences and risks of different decision alternatives. Like any other science document, the science consistency evaluation is subjected to scientific peer review. A formal and documented science consistency evaluation is not needed for all decisions but will be done for any decision that poses high risk to ecological, economic, or social sustainability.

Science information is recognized as important but only as one of the pieces of information considered in a decision. Other factors considered are clearly revealed. Science information is just that, "information." It alone does not direct an answer. 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 decisionmaking. Therefore, scientists do not advocate a particular solution to the policy or management issue (Mills and Clark 2001).

⁵ Quigley, T. et al. [1998]. Evaluation of the use of scientific information in decision-making for the Interior Columbia Basin Ecosystem Management project. Manuscript in preparation. On file with: USDA Forest Service, Pacific Northwest Research Station, 1401 Gekeler Lane, La Grande, OR 97850.

Figure 3—Barriers to science-based decisionmaking.

- The research and policymaking processes and cultures are significantly different.
- If the research and development program is too closely associated with final decisions, that association could undercut scientific credibility.
- Researchers sometimes inappropriately advocate policy positions in the decisionmaking process.
- National Forest System professional staffs sometimes inappropriately advocate positions during the decision process.
- Not all research and development scientists have the expertise or incentives to provide the science information for decisionmaking.
- Not all National Forest System professional staff has the expertise or incentives to synthesize the available scientific information and apply it to decisionmaking.
- There are too few mechanisms and personnel to accomplish the timely transfer of new scientific knowledge for decisionmaking.
- Forest Service decisionmakers do not always use the full breadth of the scientific information available.

**Barriers to
Science-Based
Decisionmaking**

Many barriers must be considered if the vision for science-based decisionmaking is to be achieved and the capabilities of the research and development program are to be protected (fig. 3).

The research and policymaking processes and cultures are significantly different and sometimes even seemingly unintelligible to each other. The role of the decisionmaker is to make the normative choice among the options and to seek common ground and agreement. The decisionmaker makes what are inherently value choices among divergent tradeoffs and seeks consensus (USDA Forest Service 1995). 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 be harnessed to generate a synergy that is not available from either cultural perspective alone.

If the research and development program is too closely associated with final decisions, that association could undercut the credibility that was the foundation of scientific independence. Forest Service Research and Development involvement is valued because it brings expertise and knowledge to complex issues. Moreover, it brings credibility and legitimacy to the deliberations. That credibility is in part the product of the organizational independence of the research and development program. If Forest Service Research and Development scientists are too closely involved in or associated with controversial policy or management decisions, the credibility of the program will be undercut and eventually lost. The credibility loss can be avoided if the input of scientists into the decisionmaking process carefully protects their independence and objectivity.

Researchers sometimes inappropriately advocate policy positions when they become immersed in the decisionmaking process. 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 certain and swift if the researcher advocates value-laden policy positions. A variant on this theme is that the decisionmaker asks the researcher to advocate a policy position because the decisionmaker wants the credibility that the mantle of research brings (USDA Forest Service 1997a). This potential problem can be avoided if researchers are provided and follow clear guidelines about their roles (Mills and Clark 2001, Mills et al. 1998).

National Forest System professional staffs sometimes inappropriately advocate positions during the decision process. The professional staff should ensure the appropriate consideration and use of science information in the decision process and the decision. Sometimes, the professional staff advocates policy positions based on their individual personal values or their disciplinary perspective rather than synthesizing and applying the full body of scientific information so that the decisionmaker can be better informed. Just as when research scientists do this, it is to the detriment of their credibility as an independent source of sound scientific information. This potential problem can be avoided if National Forest System professional staff are provided and follow clear guidelines about their roles.

Not all research and development scientists have the expertise or incentives to effectively provide the science information for contentious decisionmaking issues. Few research scientists have the skills and temperament to work effectively at this interface. Being a capable researcher is not enough. Because work at the science-policy interface is not and should not be the only role of research and development, not all researchers need to have these skills, but too few have them now. This barrier will be overcome once researchers have developed the skills to understand and work effectively at the interface with decisionmakers and are consistently rewarded for those efforts.

Not all National Forest System professional staff have the expertise or incentives to effectively synthesize the available scientific information and apply it to decisionmaking. Too few National Forest System professional staff keep current with scientific advances to be able to synthesize the relevant science for decision-making. As the advance of research knowledge outpaces the ability of the professional staff to stay up-to-date, this gulf widens. A common solution is to have the research scientist fill the void left by an inadequate professional staff. Although a successful short-term strategy, in the long run this will undermine the credibility of the professional staff and diminish the capability of the research and development program to develop new scientific knowledge through research. The result will be disastrous to the ability of the agency to bring science into decisionmaking on a sustainable basis. This barrier can be overcome once professional staffs have been given the time and provided the necessary skills and appropriate rewards to accomplish the syntheses of science information.

Too few mechanisms and appropriately trained personnel exist to accomplish the timely transfer of new scientific knowledge to professional staff and decisionmakers. The current mechanisms for technology transfer are inadequate. Resource managers complain about the inadequacies of the research and development program's technology transfer. Research and development 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 research and development scientists, professional staff, and line officers is effective at transferring new science information to those particular staff and line officers, but dispersion of the new knowledge beyond those few is spotty. The agency needs to develop and appropriately reward a cadre of specialists who can effectively span the boundary between research results and management application and can communicate with both research scientists and resource managers.

Forest Service decisionmakers do not always use the full breadth of the scientific information available. 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. Those steps require more disclosure than is sometimes included in National Environmental Policy Act (NEPA) documents. 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, some decisionmakers do not have the capability or inclination to fully and completely consider the science information. The Forest Service will overcome this barrier once the decisionmakers are afforded the opportunity and exhibit the commitment to develop the skills and understanding necessary to fully consider all relevant scientific information.

Figure 4—Proposed solutions.

1. Increase funding in order to expand the Forest Service's capability to generate the science foundation for decisions:
 - a. Increase the scientific capability of the Forest Service Research and Development program.
 - b. Increase the capability of National Forest System professional staff to effectively utilize available science information.
 - c. Determine how the costs of providing science information should be shared between the National Forest System and Research and Development.
2. Establish clear role expectations and expand the mechanisms to transfer and assimilate scientific knowledge:
 - a. Clarify what science information will be provided for each decision.
 - b. Clarify who is responsible for developing the necessary science information.
 - c. Clarify how Research and Development scientists will provide science information to the decisionmaking process.
 - d. Clarify how National Forest System professional staff will develop and use scientific information.
 - e. Clarify how Research and Development administrators will contribute to ensuring that science information is effectively brought to the National Forest System decisionmaking process.
 - f. Clarify how Forest Service decisionmakers will use scientific information in their decisions.
 - g. Conduct formal evaluations of the consistency of major decisions with available science.
 - h. Improve the management of the research development scientists while they are involved in major decision issues.
 - i. Develop mechanisms to promote the effective transmission of new science information so as to expand the science capability of the National Forest System professional staff.

Proposed Solutions

Two groups of actions are necessary to address the dual issues of how to ensure that science-based decisions are the norm for national forest management and how to simultaneously protect the ability of the research and development scientists to conduct a research program that generates new scientific information and retains scientific credibility. The first and most important action is to provide the funding to expand the capability of Forest Service Research and Development and the National Forest System professional staff commensurate with the expanded magnitude and complexity of the job of making science-based decisionmaking the norm. The next is to clarify performance expectations and more proactively manage available staff and scientific information.

Partial solutions will not be successful at addressing these two issues. Instead, a complete set of actions must be taken. Although the proposed solutions are listed separately below, they are interrelated and mutually supportive (fig. 4).

Increase Funding to Expand the Forest Service's Capability of Generating a Science Foundation for Decisions

- a. **Increase Forest Service Research and Development capability.** Add a funding increment to the Forest Service Research and Development program commensurate with the cost of fulfilling this greatly expanded mission of contributing science information at the policy and management interface. Although it has not yet been determined what increase in funding would be necessary, it is clear that the increase would need to be significant if Research and Development is to be materially involved in all major national forest management decisions (especially if that includes involvement in all national forest plan revisions).⁶ This funding increase should be provided in a timely manner and focused exclusively on building the capacity to effectively provide science information to the decision process. Just as in past efforts, universities would play an important role, with Forest Service Research and Development assuming a major responsibility in most situations.
- b. **Increase the capability of National Forest System professional staff to effectively use available science information.** Add a National Forest System funding increment to upgrade professional staff capability to permit full use of available scientific information in the decision process. This funding increase should be focused exclusively on building the capacity to effectively accept, assemble, and use science information in decisionmaking. Just as with the increase for the Research and Development program, these funds would be used to bring the science information to bear through the help of others, especially university scientists.

⁶ Background information that helps explain the size of the needed research program funding increase are estimates of the forest planning costs that range from \$250 million annually by the Government Accounting Office (1997) to as much as 40 percent of the National Forest System appropriation by the National Association of Public Administrators. The future costs of the science contributions are likely to be higher than in the past, especially for the science component of assessments and decisionmaking, given the emphasis placed on increased consideration of science in the National Forest Management Act planning rule.

**Establish Clear
Role Expectations
and Expand the
Mechanisms to
Transfer and
Assimilate Scientific
Knowledge⁷**

- c. Determine how the costs of providing the science information should be shared between the National Forest System and Research and Development.** Because the primary purpose for developing science information for national forest management decisions is to improve those decisions, most of the cost for generating that information should be paid with National Forest System funds. On the other hand, some of the efforts to generate science information also will provide research benefits to the Research and Development program objectives. Guidelines that clarify the appropriate share of funding are needed to remove funding as a point of tension between the programs.
- c. Clarify what science information will be provided for each decision.** For each decision, clarify what science products are needed. Options include assistance with the clarification of issues and problem framing, a synthesis of already available scientific information, development of new information, identification of management options, the estimation of the consequences and risks of specific management alternatives, and an evaluation of whether the decision is consistent with available science information.
- d. Clarify who is responsible for developing the necessary science information.** Clarify whether research and development scientists or National Forest System professional staff are responsible for providing all or parts of the science information. Although either might be the lead, scientific input would most likely be sought from other sources as well, especially from universities. Lead responsibility should be determined by available expertise and the relative importance of the independence achieved through organizational distance from the decisionmaker; i.e., the more that independence from the decision is needed, the more likely that Research and Development should take the lead rather than professional staff.
- e. Clarify how research and development scientists will provide science information to the decisionmaking process.** Clearly define the roles for research scientists when they play a part in bringing the science information to the decision process, including how to avoid inappropriate advocacy of any particular solution or position. Increase the cadre of Research and Development scientists who have the requisite capabilities to fill the science role in decision-making by assigning them to the science role of decisionmaking efforts under the supervision of an experienced science provider.
- f. Clarify how National Forest System professional staff will develop and use scientific information.** Professional staff are expected to present the full context and substance of relevant scientific information, unbiased by the pressures of the decisionmaking process. Whenever they take the lead in developing and presenting the science information for a decision, they should provide that science role fully. For example, they should present the consequences and risks of management alternatives through rigorous use of the scientific information, and they

⁷ Guidelines for the use of science information and the behavior expected from the various players have already been enumerated, especially in USDA Forest Service 1995 and 1997. The behavior expectations listed here are deemed to be the most vital to success.

should refrain from advocacy that could detract from their objectivity and credibility. Increase the cadre of professional staffs who are capable of filling the science role in decisionmaking by assigning individual National Forest System professional staff as boundary spanners under Research and Development leadership in ongoing efforts to provide science information to particular decisions.

- g. Clarify how Research and Development administrators will contribute to ensuring that science information is effectively brought to the National Forest System decisionmaking process.** Administrators should emphasize the priority of contributing science information to the decision process and reward those individuals who successfully accomplish this task. The role, if any, that Research and Development administrators should play should be clarified even when Research and Development scientists are not involved and others, such as National Forest System professional staff, are primarily responsible for providing the science information for a decision.
- h. Clarify how Forest Service decisionmakers will use scientific information in their decisions.** Decisionmakers must openly and fully use all the scientific information that is presented to them. They must demonstrate through their decision and decision rationale that the science information was an important foundation of their decisions.
- i. Conduct formal evaluations of the consistency of major decisions with available science.** Evaluate whether major national forest management decisions are consistent with available scientific information. Research and Development scientists should lead the evaluation on the most contentious decisions because of their greater organizational distance from the decisions, and National Forest System professional staff should lead the evaluation on decisions with a lower level of controversy. Subject the consistency evaluations to scientific peer review, just as is done for other important science documents, regardless of who develops it. A formal and documented science consistency evaluation is not needed on all decisions but should be done for any decision that poses a high risk to ecological, economic, or social sustainability.
- j. Improve the management of the Research and Development scientists while they are involved in major decision issues.** Research and Development administrators must provide improved training to help scientists work more effectively at the science and policy interface and improve the reward system to recognize effective contributions. At the beginning of long-term assignments, the charter for the work should clearly describe the expectations for the roles of the research scientists, especially the products they are expected to provide and how they will interface with the decision process. There also should be clear employee-manager agreements covering the transition of the scientists from their research assignment to their science and policy assignment, and their return to research (USDA Forest Service 1998).

k. Develop mechanisms to promote the effective transmission of new science information so as to expand the science capability of the National Forest System professional staff. The following organizational changes would contribute to a more rapid and complete transmission and assimilation of new scientific information:

- Further develop continuing education training programs that provide professional staff the latest scientific information and give them the tools to effectively use that information in their work in all programs.
- Increase technical certification for professional staff with required periodic renewal to ensure that they have up-to-date scientific skills.
- Establish expert planning teams to assist decisionmakers and professional staff in bringing science information to bear in particularly difficult land management decision processes; e.g., in evaluating risk and species viability, somewhat like an internal extension service.
- Establish temporary national teams to further develop science syntheses and science-based tools on selected topics, (e.g., watershed analysis techniques) and transfer those improved techniques to National Forest System professional staff for use in the decision process.
- Use decision-support systems technology to package science information so it is most useful and accessible to professional staff and decisionmakers.

Conclusion

Several actions must be taken promptly to ensure that National Forest System decisions are appropriately informed by science without jeopardizing the capability of Forest Service Research and Development. The resulting benefits cannot be realized if the Research and Development program is focused solely on assembling science information for National Forest System decisions. In addition, current staffing and funding are insufficient to address the significant job the Forest Service is facing. Other actions are needed if the Forest Service is to achieve the vision of accomplishing science-based decisions about land management on the national forests.

Those actions include providing adequate funding and staffing for the National Forest System and for Forest Service Research and Development. They include new ways to manage the scientific staff, and new mechanisms to transfer science information and its consideration in decisionmaking. The proposed actions are vital for the Forest Service to improve the science basis of national forest management decisions and simultaneously protect the capability and credibility of the research and development program.

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