5 Putting Science into Action on Forest Service Lands

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It can be safely said when it comes to actual work on the ground, the objects of conservation are never axiomatic or obvious, but always complex and usually conflicting.

—Aldo Leopold (in Flader and Callicott [1991:83])

ABSTRACT

The U.S. Forest Service includes three main branches: National Forest Systems, Research and Development, and State and Private Forestry. Herein, we focus on National Forest Systems and Research and Development. National Forest Systems is the management branch of the agency, and its charge is to administer national forests and grasslands throughout the United States. A number of laws, statutes, and policies guide and direct how forests should be managed, including provisions for considering and applying the best available science when planning and executing management actions. The Research and Development branch of the Forest Service is separate from the Management branch and this separation is purposeful. Its charge is to design and conduct research to provide the scientific basis for natural resource management on Forest Service lands. Even though these two branches of the Forest Service are separate, they are linked by virtue of being within the same agency. This linkage reflects the intent for management of Forest Service lands to be guided by the best available science, a concept deeply embedded within the National Forest Management Act (NFMA) and the enabling regulatory language. Despite the intent of Congress, application of science to management has been variable and has changed with each revision of the implementing language (i.e., planning rule) for NFMA. Our objectives here are to review the historical and current roles of science in guiding management of wildlife on national Forest Service lands. We will draw on case studies (Mexican spotted owl [*Strix occidentalis lucida*] and sensitive northwestern woodpeckers) to illustrate situations where science was heeded and where it was not for managing these species, and discuss the ramifications of doing so.

INTRODUCTION

The U.S. Forest Service (hereafter Forest Service) is within the federal government's Department of Agriculture. The Forest Service was established in 1905 and is the largest natural resource organization in the world. The overall mission of the 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" (U.S. Forest Service 2012). It has management responsibility for 78 million hectares of forest, woodland, grassland, and desert, and partners with other organizations in the management of an additional 200 million hectares of rural and urban lands.

The Forest Service is partitioned into five primary mission areas: Research and Development, National Forest Systems, State and Private Forestry, International Programs, and Business Operations. The focus of this chapter is the relationship of Research and Development to National Forest Systems. Although mission areas of both are somewhat intertwined, they are distinct in that they are not joined until the Office of the Chief. This is a key point because it conveys independence between science and management (Ruggiero 2009).

A number of laws, statutes, and policies guide and direct how forests should be managed, including provisions for considering and applying the best available science when planning and executing management actions. The Research and Development branch of the Forest Service is separate from the management branch and this separation is purposeful. Its charge is to design and conduct research to provide the scientific basis for natural resource management on Forest Service lands. Scientists require autonomy to pursue avenues of research unencumbered by the political reality of managers. This independence is critical to ensuring that research results are considered unbiased and not unduly influenced by managers' needs. Lacking this independence, credibility of scientific research could be questioned and management based on it subjected to challenge (Ruggiero 2010).

Even though these two branches of the Forest Service are separate, they are linked by virtue of being within the same agency. This linkage reflects the intent for management of Forest Service lands to be guided by the best available science, a concept deeply embedded within the National Forest Management Act (NFMA) and the enabling regulatory language. The act specifically states that "… the new knowledge derived from coordinated public and private research programs will promote a sound technical and ecological base for effective management, use, and protection of the Nation's renewable resources." Despite the intent of Congress, application of science to management has been variable and has changed with each revision of the implementing language (i.e., planning rule) for NFMA.

Our objectives here are to review the historical and current roles of science in guiding management of wildlife on National Forest Service lands. We will draw on case studies (Mexican spotted owl [*Strix occidentalis lucida*], and sensitive northwestern woodpeckers) to illustrate situations where science was heeded and where it was disregarded for managing these species, and discuss the ramifications of doing so.

LAWS AND REGULATIONS ESTABLISHING THE ROLE OF RESEARCH IN THE MANAGEMENT OF NATIONAL FOREST SERVICE LANDS

A number of laws and regulations underlie establishment of the Forest Service and management of national Forest Service lands. We review them briefly here.

FOREST SERVICE ORGANIC ADMINISTRATION ACT (1897)

Governs the administration of national forest lands, outlines the establishment of forest reserves, and provides for their protection and management.

McSweeney–McNary Forest Research Act (1928)

Enables the Forest Service to conduct scientific research for a wide range of information users.

National Environmental Policy Act (1970)

Requires federal agencies to consider environmental impacts in their decision-making processes when considering their proposed actions and reasonable alternatives to those actions. During the scoping process, the action agency must consider all relevant information in developing a proposed action and alternatives. Information provided through research often provides the basis for that information.

Endangered Species Act (1973)

Specifies procedures for designating threatened and endangered species, recovery planning, and interagency consultation to evaluate effects of management that could affect species or their habitats. Listing species as threatened or endangered, developing recovery plans, interagency consultations, and decisions on whether to delist depend heavily on the best available scientific information.

National Forest Management Act (1976) or NFMA

Requires the Secretary of Agriculture to assess forestlands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan (also known as a forest plan) for each unit of the National Forest System. The act is implemented through planning regulations. These planning regulations, or planning rule, have been in flux since first developed in 1979. Individual forests and grasslands follow the direction of the planning rule to develop a land management plan specific to their unit. Presently, most forests and grasslands are operating under the 1982 planning rule or an interim planning rule that relies heavily on science consistency to ensure that forest plans and decisions consider the best available science. Through the 1982 regulations, each forest must provide habitat capable of maintaining viable populations of selected species, and are directed to select Management Indicator Species (MIS) to help ensure species viability. MIS are defined as "plant and animal species, communities, or special habitats selected for emphasis in planning," which are *monitored* during forest plan implementation to assess effects of management activities on their populations and other species populations with similar habitat needs.

Forest and Rangeland Renewable Resources Research Act (1978)

Authorizes expanded research activities to obtain and disseminate scientific information about protecting, managing, and using renewable resources. The Act contains an extensive list of research activities, including those related to maintaining and improving wildlife and fish habitats, and protecting threatened and endangered flora and fauna. The Act also authorizes international research. This authorization distinguishes Forest Service Research from other federal natural resources research organizations.

Forest Service Manual (FSM 1999)—National Forest Resource Management (last modified 1999)

Defines sensitive species as those plant and animal species identified by a Regional Forester for which population viability is a concern, as evidenced by significant current or predicted downward trends in populations or in habitat capability that would reduce a species' current distribution. Objectives for designated sensitive species include implementing management practices to ensure that species do not become threatened or endangered because of Forest Service actions.

FOREST SERVICE RESEARCH (FSR)

The overarching mission of FSR is "to serve and benefit society by developing and communicating the scientific information and technology needed to manage, protect, use, and sustain the natural resources of forests and range lands" (U.S. Forest Service 2012). Most research is organized around seven strategic program areas: (1) fire and fuels, (2) resource management and use, (3) wildlife and fish, (4) recreation, (5) water and air, (6) inventory, monitoring, and analysis, and (7) invasive species. Specific national focus areas are dynamic and often reflect current issues and public concerns. Examples of current focus areas include inventory and monitoring, climate change, ecological restoration, and urban natural resource stewardship. Much of this research tends to be applied, but some work is conducted to acquire basic knowledge of ecosystem processes and functions.

The McSweeney–McNary Forest Research Act of 1928 (supplanted by the Forest and Rangeland Renewable Resources Research Act of 1978) mandates the Forest Service to conduct scientific research to provide the basis for the management of natural resources. Policy set forth in the FSM describes the role of research and specifies that research should function as a separate entity with scientific freedom to define its research portfolio. That is, ultimate decisions on topics to address and studies to conduct are made independently by research without undue influence from the management branch. That is not to say that managers and other stakeholders are left out of the process. Development of focal areas is done with extensive input from stakeholders and partners. Perhaps the chief stakeholder is National Forest Systems; thus, much of the research is geared to focus on their needs.

The research and development (R&D) arm of the U.S. Department of Agriculture (USDA) Forest Service works at the forefront of science to improve the health and use of our nation's forests and grasslands. Research has been part of the Forest Service mission since the agency's inception in 1905. Today, some 500-plus Forest Service researchers work in a range of biological, physical, and social science fields to promote sustainable management of our nation's diverse forests and rangelands. Their research occurs in all fifty states, U.S. territories, and commonwealths. The work has a steady focus on informing policy and land management decisions, whether it addresses invasive insects, degraded river ecosystems, or sustainable ways to harvest forest products. Researchers work independently and with a range of partners, including other agencies, academia, nonprofit groups, and industry. The information and technology produced through basic and applied science programs is available to the public for its benefit and use.

FSR is broken into seven research stations. Five are geographically oriented whereby the research done is to address pressing needs within that area. Two stations are national in scope, one directed at forest products and the other, tropical forests. Focus areas become more refined at the station level and then within individual research units. Research units develop five- to ten-year charters and these charters establish the umbrella under which research will be done.

NATIONAL FOREST SYSTEMS (NFS)

National Forest Systems is the management branch of the U.S. Forest Service. As with FSR, NFS is partitioned geographically with nine broad regions and individual national forests reside within each region. Management within national forests is articulated with forest plans (Land and Resource Management Plans). Direction for developing forest plans originated in the National Forest Management Act (1976), and this direction is implemented through established planning regulations and policy direction in the FSM. These planning regulations are in continual flux, reflecting both new priorities and approaches for managing forests and grasslands. Presently, a revision of the planning regulations is undergoing public review and comment.

At the national level, seven major goals comprise the Forest Service Strategic Plan through 2012. These include: (1) restore, sustain, and enhance the nation's forests and grasslands, (2) provide and sustain benefits to the American people, (3) conserve open space, (4) sustain and enhance outdoor recreation opportunities, (5) maintain basic management capabilities of the Forest Service, (6) engage urban America with Forest Service programs, and (7) provide science-based applications and tools for sustainable natural resources management. Although all are germane to the research-management interface, the primary goal relevant to the research-management interface is goal 7.

THE INTERSECTION OF SCIENCE AND MANAGEMENT

Science is the process of acquiring new information following a systematic design (Hull 1988). Science can range from observational studies to true experiments, and objectives range from describing natural phenomena to understanding effects of management options on selected response variables. As such, research runs the gamut of traditional hypothesis testing to parameter estimation. Research can be applied or basic; it can be visionary or responsive to specific information needs. Regardless, it must be objective such that the design should not be to support a particular viewpoint, but to acquire reliable information to guide resource management decisions.

This independence is key to maintaining research credibility within the scientific community and with the public. The separation between the research and management branches of the Forest Service is reinforced by appropriations law, whereby funds provided directly to research and development by Congress can be applied only to research activities and not management. Funds provided to the management branch,

however, can be applied to administrative studies and monitoring. Administrative studies are typically short-term in nature and used to address a specific issue at a given location. Monitoring is the responsibility of NFS and is broken into four primary types: implementation, effectiveness, validation, and compliance (Morrison and Marcot 1995). Implementation monitoring focuses on whether a proposed management action was implemented as described in a project plan. For example, if a treatment calls for reducing tree basal area by 50%, did the treatment meet that goal? Effectiveness monitoring evaluates whether the treatment met the stated goal. For example, if a treatment was done to increase northern goshawk (*Accipiter gentilis*) populations, did population numbers actually increase? Validation monitoring relates to the concordance between management activities and standards and guidelines established by policy (e.g., forest plans). Compliance monitoring tracks how well the Forest Service meets the intent of actions proscribed by statute. An example would be meeting take limitations for an endangered or threatened species under the Endangered Species Act. Often, NFS lacks the expertise to design and implement key administrative studies or monitoring. In some cases, they will approach Research for assistance in which case Research will consult with NFS and provide advice, or actually conduct the study.

Monitoring is also critically important to the adaptive management process (Moir and Block 2001). The Forest Service has long espoused adaptive management as a cornerstone of its management efforts. As management actions are applied, information that details the efficacy of those actions is critical to future efforts. If the actions meet stated objectives, they should continue. If not, perhaps they should be revised and different approaches are warranted. Three key questions should be addressed with respect to monitoring within an adaptive management framework. First, was monitoring designed to correctly assess effects of management? Included here are considerations of the selection of the appropriate response variables and evaluation of the adequacy of the sampling design. Second, were protocols followed and was the design implemented correctly? If these first two questions are addressed adequately, then how do monitoring results influence subsequent management direction? Research can help to address the first two aspects, specifically to ensure that managers have reliable knowledge to form the basis of future management decisions.

Science is not done to support or refute management. The goal of science is to provide the best available information for informed decisions. This raises a key point regarding the separation of science from policy. The wisdom here is that science should inform but not dictate policy (Ruggiero 2010). If scientists are cast in the policy arena, their credibility and objectivity can be called into question. Further, numerous factors, not just science, must be considered when formulating policy. These decisions are best left to those who must weigh often competing information when selecting among management options or establishing long-term policies.

CASE STUDIES

White-Headed Woodpeckers

The white-headed woodpecker (*Picoides albolarvatus*) has been considered a Management Indicator Species (MIS) by several National Forests in the inland

Northwest since the 1990s and designated more recently as a Sensitive Species by the Intermountain and Pacific Northwest Regions of the NFS. Both regions have sought the assistance of FSR on monitoring habitat and populations of the white-headed woodpecker and other woodpecker species for making science-based decisions for the conservation of sensitive woodpecker species. We provide this example as a case study of the procedures taken by the NFS in conjunction with FSR for the goal of applying the best available science for management of a Sensitive Species on public lands.

The white-headed woodpecker is a regional endemic species of the inland Northwest and California, and is strongly associated with dry coniferous forests dominated by ponderosa pine (*Pinus ponderosa*) (Garrett, Raphael, and Dixon 1996; Wightman et al. 2010; Hollenbeck, Saab, and Frenzel 2011). They are dependent on the seeds of large-coned pines (e.g., ponderosa pine, sugar pine [*Pinus lambertiana*]) for a portion of their diet (Raphael and White 1984). This woodpecker typically nests in mature, open forests with large-diameter trees and a relatively sparse canopy (Hollenbeck et al. 2011), but also nests in recently burned forests (Wightman et al. 2010). The white-headed woodpecker may be particularly vulnerable to environmental change because it occupies a limited distribution and has narrow habitat requirements. The loss of large-diameter snags and the conversion of pine-dominated forests to other forest types have been implicated in the potential decline of their populations (Garrett et al. 1996), although documentation of population declines is sparse (Marshall, Hunter, and Contreras 2003).

National Forests in the Pacific Northwest Region use results of a large-scale environmental assessment for land-use planning throughout the interior Columbia Basin ecosystem (Wisdom et al. 2000). This assessment reported that the white-headed woodpecker was one of only eight of the ninety-seven species analyzed that showed strong declines in habitat (>60% decline from historical conditions) (Wisdom et al. 2000). Presumably because of habitat decline, population declines and range retractions have occurred. In a Central Oregon study, reproductive success of white-headed woodpeckers appears too low to offset adult mortality (Hollenbeck et al. 2011). Survey efforts during the early 2000s yielded no white-headed woodpeckers at some locations in Oregon where they were once considered common in the late 1970s (Altman 2002). Managers are concerned about the status of the white-headed woodpecker not only because of declines in habitat and because of potential declines in populations, but also because dry coniferous forests are the focus of restoration activities in the inland Northwest (Marshall et al. 2003). Consequently, managers identified the need to predict potential wildlife habitat in landscapes affected by restoration activities to help with timely decisions regarding treatment options.

Beginning in 2002, the Pacific Northwest Region (R6) sought assistance on population and habitat monitoring of woodpeckers from Rocky Mountain Research Station (RMRS) researchers because they were considered experts on the ecology of cavity-nesting birds (e.g., Saab, Dudley, and Thompson 2004). With funding support by the NFS (R6) and FSR, RMRS researchers developed models of habitat suitability and nest survival of white-headed woodpeckers in burned and unburned forests (Wightman et al. 2010, Hollenbeck 2011). In 2009, the Pacific Northwest Region assembled a team of biologists to develop a conservation assessment and strategy for the white-headed woodpecker (Mellen-McLean et al. 2010). The team leader is the regional wildlife ecologist, co-lead is a research wildlife biologist, and other team members include NFS biologists, the Bureau of Land Management (BLM) biologists, and FS researchers.

The conservation assessment and monitoring strategy is a key element of a six-year commitment by R6 on "Dry Forest Habitat Condition and Trend Monitoring." The monitoring strategy was designed under an adaptive management framework. The intended outcome is to provide biologists and land managers with guidance on the locations, priorities, and types of landscape- and stand-scale prescriptions that can be used to maintain or increase areas of suitable habitat for the white-headed woodpecker and increase forest resiliency under current and future climate scenarios.

The conservation strategy has three components:

1. Broad-scale occupancy and vegetation monitoring—designed to provide reliable, standardized data on the distribution, site occupancy, and population trends for white-headed woodpeckers across their range in Oregon and Washington. A pilot of this monitoring occurred in 2010, providing the basis for sample sizes needed to estimate selected values of occupancy adjusted for detection. In addition to the occupancy monitoring, vegetation data are collected regionally for input into a fire-climate model to predict future conditions (Keane, Loehman, and Holsinger 2011). Beginning in 2011, the monitoring is expected to be funded by the NFS for six years with additional support by the BLM of Oregon and Washington for the fuels data collection.
2. Validation monitoring—designed to field test and refine models of nesting habitat suitability for current conditions (Wightman et al. 2010, Hollenbeck et al. 2011). Field data collection and model development for habitat suitability took place from 1997 to 2009 and was funded primarily by Oregon Department of Fish and Wildlife and NFS, with additional support by the Oregon chapter of The Nature Conservancy, and FSR. Starting in 2010, models were field tested in locations of model origin. Field-testing will be followed by model refinement, and finally models will be applied to new locations in the region. In addition to refinement of the habitat suitability models that describe current conditions for woodpeckers, a simulation-modeling component is being used to identify habitat areas that are vulnerable to effects of climate change, and to identify management strategies that may promote landscape resilience (Keane et al. 2011). This effort is primarily funded by FSR with additional funding and logistical support by the NFS.
3. Treatment effectiveness monitoring-adaptive management—designed to evaluate the effectiveness of silvicultural treatments that incorporate information from the validated habitat suitability models in reducing fuels, restoring dry forests, and creating-maintaining habitat for white-headed woodpecker across Oregon and Washington. This monitoring began in 2011 at one site in central Oregon. The plan is to add a network of sites over a six-year period. Currently, this effort is funded primarily by FSR with support from the NFS.

Time has not allowed for implementing adaptive management related to the R6 white-headed woodpecker conservation and monitoring strategy. However, the time and money (roughly $50,000 to $160,000 annually from 1997 to 2011) committed by the NFS indicate that adaptive management has a good chance of success. The procedures for the population and habitat monitoring are scientifically rigorous. The population monitoring will provide accurate and precise estimates of occupancy rates, and the vegetation monitoring will provide trends in habitat capability that could influence the current or future distribution of the white-headed woodpecker. Such information is necessary to help prevent the listing of Sensitive Species as a candidate for a threatened or endangered species.

Mexican Spotted Owl

The Mexican spotted owl was listed as a threatened species under the Endangered Species Act in 1993. A recovery team was assembled and a recovery plan was completed and approved in 1995 (USDI Fish and Wildlife Service 1995). The recovery team had strong representation from FSR. This was largely because Forest Service researchers either conducted or collaborated on most of the research done and were regarded by many as experts on the species (cf., Ganey, Ward, and Willey 2011). We present this example because it serves as a good case study of the application of science to management on National Forest Systems lands.

Although the Mexican spotted owl occupies a broad geographic range extending from Utah and Colorado south to central Mexico, it occurs in disjunctive locations corresponding to isolated mountain and canyon systems. The current distribution mimics its historical extent, with the exception of its presumed extirpation from some historically occupied locations in Mexico and riparian ecosystems in Arizona and New Mexico. Of the areas occupied, the densest populations of owls are found in mixed-conifer forests, with lower numbers occupying pine-oak forests, encinal woodlands, rocky canyons, and other habitats. Habitat-use patterns vary throughout the range of the owl and with respect to owl activity. Much of the geographic variation in habitat use corresponds to differences in regional patterns of vegetation and prey availability. Forests used for roosting and nesting often exhibit mature or old-growth structure; they are uneven-aged, multi-storied, of high canopy closure, and have large trees and snags. Little is known about foraging habitat, although it appears that large trees and decadence in the form of logs and snags are consistent components of forested foraging habitat. The quantity and distribution of owl habitat, as well as of areas that can be expected to support the necessary habitat correlates in the future, are poorly understood.

The recovery team assembled and reviewed all existing information on the ecology of the Mexican spotted owl, existing forest conditions and trends, and potential threats to the owl (Ganey and Dick 1995; USDI Fish and Wildlife Service 1995). This information provided the scientific basis for developing management recommendations, which were variously applied on the ground. The recovery plan was a combination of prescriptive site-specific guidance and descriptive desired conditions to strive for on the landscape. The underlying philosophy of the recovery team was that the plan should emphasize adaptive management, whereby recommendations would be adjusted as information was acquired to evaluate their effectiveness. As such, the plan was cast as a three-legged stool with management recommendations, habitat monitoring, and population monitoring representing the legs of the stool. The analogy to a stool means that if any one of the legs was removed, the recovery plan could fail. This concept was reinforced by the delisting criteria, which required strong evidence for stable or increasing habitat and populations.

The recovery plan designated three primary management areas: protected areas, restricted areas, and other forest and woodland types. The rationale was to protect areas currently occupied by owls and those with a high likelihood of occupancy (protected areas), manage for replacement nest and roost habitat (restricted areas), ensure the presence of key habitat elements for what the owl required for foraging and dispersal (restricted areas), and maintain connectivity (other forest and woodland types).

Management was most prescriptive within protected areas. Much of this entailed establishing a 243-ha (600-acre) protected activity center (PAC) around owl nest/roost areas within which little active management should occur. The recovery team recognized the need to reduce fuels within selected PACs. The failure to do so could render these PACs vulnerable to stand-replacement fire and loss of the habitat altogether. Treatments within PACs should be within an adaptive management framework, whereby effects of treatments on owls and their habitat would be monitored and assessed. The recovery team recommended a staged approach where up to 10% of the PACs could be treated by thinning trees <22 cm diameter breast height (DBH) and effects of those treatments would be assessed to identify the next course of action. Depending on the outcome of these assessments, treatments could continue, discontinue, or be adjusted. Despite this opportunity, an assessment never took place.

Management within restricted areas focused on creating replacement nest-roost habitat and managing to meet other land-use objectives. Restricted areas included mixed-conifer and pine-oak forests. Agencies were required to conduct landscape analyses to identify 10 to 25% of the restricted area and to manage those areas to become replacement nest-roost habitat. This percentage was based on modeling to identify that which could be sustained in this condition given ecology of these forest types. The remaining restricted area had few constraints other than to retain key habitat components such as large trees, snags, logs, and hardwoods. The habitat components were identified through a series of research studies that demonstrated strong correlations between them, the owl, and their prey (Ward 2002, Block et al. 2005).

As noted previously, monitoring both populations and habitat were critical to assessing how well the recovery plan was working at recovering the owl and leading to its delisting. With the exception of a few owl demographic studies and some general inventories, little is known about the population status of the Mexican spotted owl. Even these studies were limited in scope and objectives, and are unsuitable for projecting range-wide population trends. Consequently, the recovery team considered and re-analyzed existing data (White, Franklin, and Ward 1995) and used that as a basis for developing a rigorous approach for population monitoring. As conceived, the population-monitoring program in the Mexican spotted owl recovery plan was thought to be scientifically defensible and would provide accurate and precise estimates of population trend. However, a program that is conceived must be tested through a pilot study prior to implementation. The Southwestern Region of the Forest Service provided funding in 1999 to conduct a pilot study. The approach had merit, but logistical considerations and other factors led Ganey et al. (2004) to conclude that it was infeasible. No progress has been made to revise or implement population monitoring since then.

Habitat monitoring was proposed at two spatial scales—macro- and microhabitat. Macrohabitat monitoring was to evaluate changes in habitat quantity at large landscape or regional scales. It entailed conducting change-detection analysis based on remote-sensing data. Change detection analysis was conducted once and not continued. Microhabitat monitoring focused on evaluating trajectories of key habitat components (large trees, snags, logs) following habitat altering activities such as prescribed fire or mechanical treatments. A design for this was developed by an interagency team and is presented in Morrison et al. (2008). National Forest personnel collected these data, but have yet to conduct the analysis.

Gathering defensible scientific information is necessary for delisting the Mexican spotted owl. Data that clearly show that the population is stable or increasing and that adequate habitat is projected in the future would provide U.S. Fish and Wildlife Service with the basis for considering that the owl no longer requires protection under the Endangered Species Act. The recommendations for management and monitoring were based on the best available science, much resulting from studies conducted by FSR. Regardless, progress on implementing them has been delayed for various reasons. Although NFS requires high-quality information, its budgets and expertise are not keeping up with progress in wildlife science, namely the use of modern methods to monitor populations, and the need for experimental studies to realize cause and effect relationships.

LESSONS LEARNED

Wildlife science has grown exponentially over the past fifty years, especially since passage of the ESA (1973) and the National Forest Management Act (1976). Great strides have been made in the study of wildlife populations (Williams, Williams, and Conroy 2002), habitats (Morrison, Marcot, and Mannan 2006), and the design and implementation of research studies (Block et al. 2001, Morrison et al. 2008). The information garnered from these studies provides a defensible basis for managing species and their habitats, and for monitoring changes in populations in response to management practices. Are there obstacles in applying science to management? If so, are they real or perceived? Clearly, recent revisions to development of forest plans emphasizes the importance of basing management of National Forests on the best available science. Whether that occurs requires both commitment and practice. Perhaps the disconnect between the two is deeply embedded within the culture of the Forest Service. Brown and Squirell (2010) concluded that the Forest Service lacks a strong learning environment. Indeed, such a culture is required to identify, embrace, and apply new information as it becomes available. Our case studies suggest that the Forest Service is capable of applying science to management, but it is practiced unevenly. Wildlife science will continue to grow and improve. Wildlife management on Forest Service lands must keep pace with these changes and use that information to ensure conservation of species.

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