Protecting Rare, Old-Growth, Forest-Associated Species under the Survey and Manage Program Guidelines of the Northwest Forest Plan

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Abstract: *The Survey and Manage Program of the Northwest Forest Plan (NWFP) represents an unparalleled attempt to protect rare, little-known species associated with late-successional and old-growth forests on more than 9.7 million ha of federal lands. Approximately 400 species of amphibians, bryophytes, fungi, lichens, mollusks, vascular plants, arthropod functional groups, and one mammal were listed under this program because viability evaluations indicated the plan's network of reserve land allocations might not sustain the species over time. The program's standards and guidelines used an adaptive approach, protecting known sites and collecting new information to address concerns for species persistence and to develop management strategies. Since implementation in 1994, approximately 68,000 known sites have been recorded at an expense of several tens of millions of dollars. New knowledge from surveys reduced concern for nearly 100 species, and they were removed from the protection list. Although successful in protecting hundreds of rare species not typically considered in most conservation programs, some of the enacted conservation measures created conflicts in meeting other management objectives of the plan, particularly timber harvest. The program accrued important gains in knowledge, reduced uncertainty about conservation of a number of species, and developed new methods of species inventory that will be useful in future management planning and implementation at many scales. The program, however, was not completed because of changes in land-management philosophy. Ongoing litigation regarding its termination and potential changes to the plan cast further uncertainty on how the original goal of maintaining persistence of late-successional and old-growth species will be met and measured. The outcomes, controversies, and management frustrations of the program exemplify the inherent difficulties in balancing broad, regional conservation goals with social and economic goals of the NWFP. Defining acceptable trade-offs to reach that balance and developing practical conservation solutions remain challenges for the science and management communities. Lessons learned from the program provide a valuable biological and managerial reference to benefit future discussion on meeting those challenges.*

Key Words: adaptive management, coarse-filter conservation approach, fine-filter conservation approach, reserves, species persistence

Protección de Especies Raras y Asociadas a Bosques Viejos Bajos el Programa de Monitoreo y Gestión del Plan Forestal del Noroeste

Resumen: *El Programa de Monitoreo y Gestión del Plan Forestal del Noroeste representa un intento, sin paralelo, de proteger especies raras, poco conocidas, asociadas a bosques de sucesión tardía y viejos en más de 9.7 millones de ha en terrenos federales. Cerca de 400 especies de anfibios, briofitas, hongos, líquenes, moluscos, plantas vasculares, grupos funcionales de artrópodos y una de mamífero fueron incluidas en este*

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programa porque las evaluaciones de viabilidad indicaron que las tierras asignadas a la red de reservas del plan probablemente no sostendrían a las especies a lo largo del tiempo. Los estándares y lineamientos del programa utilizaron un método adaptativo, la protección de sitios conocidos y la recolección de información nueva para atender el interés por la persistencia de la especies y para desarrollar estrategias de gestión. Desde su implementación en 1994, se han registrado cerca de 68,000 sitios conocidos a un costo de varias decenas de millones de dólares. Los conocimientos nuevos, obtenidos de los monitoreos, redujo la preocupación por cerca de cien especies, y fueron removidas de la lista de protección. Aunque exitosas en la protección de cientos de especies raras no consideras en la mayoría de los programas de conservación, algunas de las medidas de conservación implementadas crearon conflictos con el cumplimiento de otros objetivos del plan, particularmente la cosecha de madera. El programa generó importantes ganancias de conocimiento, redujo la incertidumbre respecto a la conservación de varias especies y desarrolló nuevos métodos para inventariar especies que serán útiles en la futura planificación e implementación de actividades de gestión a diversas escalas. Sin embargo, el programa no se cumplió totalmente porque hubo cambios en la filosofía de la gestión de tierras. Un litigio sobre su terminación y potenciales cambios en el plan producen mayor incertidumbre en el cumplimiento y medición de la meta original de mantener la persistencia de especies de bosques de sucesión tardía y viejos. Los resultados, controversias y frustraciones del programa ejemplifican a las dificultades inherentes al equilibrio entre las metas de conservación regionales y las metas económicas y sociales del Plan Forestal del Noroeste. La definición de ventajas y desventajas aceptables para alcanzar ese equilibrio y desarrollar soluciones de conservación prácticas son retos para la comunidad de científicos y de administradores. Las lecciones aprendidas del programa proporcionan una referencia biológica y administrativa para el beneficio de futuras discusiones sobre como enfrentar a esos retos.

Palabras Clave: manejo adaptativo, método de conservación de grano fino, método de conservación de grano grueso, persistencia de especies, reservas

Introduction

The Forest Ecosystem Management Assessment Team (FEMAT 1993) was convened in 1994 under the directive of President Clinton to develop alternatives for conservation of old forest ecosystems in the Pacific Northwest (Thomas et al. 2006 [this issue]). The team's mission included "maintenance or restoration of habitat conditions to support viable populations, well distributed across their current ranges, of species known (or reasonably suspected) to be associated with old-growth forest conditions."

To address this objective, FEMAT and the subsequent environmental impact statement (USDA Forest Service & BLM 1994*a*) evaluated persistence of 1120 individual species and species groups associated with late-successional and old-growth (LSOG) forest under nine management alternatives (an environmental impact statement is the legally required federal documentation that describes the analyses of management alternatives and provides the basis for a final record of decision on a preferred management action). Analyses conducted by FEMAT and subsequent teams led to establishing the Northwest Forest Plan, which focuses in part on delineating late-successional forest reserves to conserve LSOG-associated species. The analyses suggest that 404 species and four arthropod groups need specific protection via mitigation guidelines to help ensure persistence of the species in the plan area. The mitigation for these species is described as "survey and manage" standards and guidelines in the final record of decision (USDA Forest Service & BLM 1994*b*; C4–C6, standards and guidelines are defined therein as "the rules and limits governing actions, and the principles specifying the environmental conditions or levels to be achieved and maintained"). We hereafter refer to the implementation of this mitigation as the Survey and Manage (SM) Program.

The SM Program conducted species conservation within an adaptive management framework. It combined elements of immediate protection of known sites, protection of sites newly detected from surveys, and evaluation of new information to determine levels of risk and management needs for each species under the Northwest Forest Plan. The SM Program is unprecedented in size and scope because it addresses hundreds of rare, poorly known species of bryophytes, fungi, lichens, and mollusks, and functional groups of arthropods that include taxa not typically considered for individual protection on federal lands.

The Northwest Forest Plan boundaries (the "plan area") were determined by the range of the Northern Spotted Owl (*Strix occidentalis caurina*) on federal lands mostly west of the Cascade Range in Washington, Oregon, and northern California. The dominant cover types in the plan area are moist conifer forests with mixed hardwoods dominated by Douglas-fir (*Pseudotsuga menziesii* [Mirbel] Franco), western hemlock (*Tsuga heterophylla* [Raf.] Sarg.), and true firs (*Abies* spp.) west of the Cascades crest and dry conifer forests dominated by Douglas-fir and species of *Pinus* and *Abies* east of the crest. The Northwest Forest Plan specified establishing late-successional forest reserves with the primary objective of providing current and future habitat for Northern Spotted Owls and other species associated with old-growth forest. In some late-successional reserves, management activities such as stand thinning and fire management were permitted if they would have neutral or beneficial effects to late-successional forest conditions.

The plan defined late-successional forests as 80–200 years old and old-growth forests as >200 years old with large trees and complex structure. Late-successional reserves are land allocations that typically contain mixtures of LSOG forest with young forests that would be managed to develop LSOG forest characteristics. The LSOG forest was about 34% of forest-capable land in the plan area; the most complex older forest was about 12% (Spies et al. 2006 ([this issue]). The plan established riparian reserves that vary in width according to stream order and local topography. The plan specified partial retention or restoration of old-forest conditions at some locations in the more intensively managed matrix lands and protection of local sites of rare or little-known species associated with LSOG forest conditions.

The combination of reserves and protection of individual sites and species could be viewed as application of coarse- and fine-filter management strategies, respectively, although these terms were not used by FEMAT and are not in the plan. Managing ecosystems and their component species under a coarse-filter approach usually entails delineating reserve areas and restoring natural patterns or processes of landscape-scale disturbances such as fire (Agee 1998; Armstrong et al. 2003) or roads (Reyers et al. 2001). The assumption of this approach is that management of coarse-filter elements alone provides for most or all fine-filter elements such as individual species, populations, specific microhabitat conditions, and other smaller-scale aspects of biodiversity (Hunter 1991; Haufler et al. 1996). The SM Program was established as a fine-filter (species-specific) complement to the mostly coarse-filter (reserve designation) framework of the plan.

The few studies that have tested the assumption suggest that coarse-filter reserves do not necessarily provide for all fine-filter elements, particularly rare and little-known species (Lawler et al. 2003). In the Pacific Northwest, Thomas et al. (1993) report that designating LSOG habitat conservation areas for viable populations of Northern Spotted Owls would not necessarily ensure persistence of approximately two-thirds of all other species associated with LSOG forests because of differences in species' locations and microhabitat elements, and lack of scientific knowledge. Instead, integrating both coarse- and fine-filter management approaches, with provision for handling uncertainties in knowledge of rare species through an adaptive management process, would better suffice to ensure conservation of both system and species level elements (Hansen et al. 1999; Kintsch & Urban 2002; Noon et al. 2003). Given, however, recent changes in planning regulations guiding national forest management that eliminate the mandate for viability assessments of at-risk species (Noon et al. 2003) and recent termination of the SM Program, it is pertinent to evaluate the degree to which a coarse-filter approach alone would provide for conservation of both ecosystem and species elements.

During the first 10 years of NWFP implementation, the SM Program became one of the more complex, expensive, and controversial aspects of the plan, triggering several lawsuits, and it was eventually terminated in 2004. Much of the controversy revolved around the delay or decline in timber harvest on nonreserved matrix lands, where numerous occurrence sites of species in the SM Program were found. Our objectives here were to (1) describe the challenges of implementing conservation measures for more than 400 rare, little-known species throughout the 9.7-million-ha NWFP area; (2) present the major survey results, (3) discuss the effects of implementing the SM Program on other aspects of the plan; (4) place this conservation program in the science context of integrating and testing coarse- and fine-filter conservation approaches; and (5) reflect on lessons learned and how aspects of the SM Program can be used as a model under the USFS and BLM sensitive species programs or in areas outside the Pacific Northwest.

History and Evolution as Part of FEMAT

Several biological and environmental assessments led to development of, and changes in, the SM Program, and its final disposition in 2004 (Fig. 1; Thomas et al. 2006). FEMAT broadened an earlier analysis of approximately 600 old-growth-associated species (Thomas et al. 1993) to include species associated with late-successional forests and to address additional federal lands not previously considered. Using ecological information and criteria to identify species closely associated with LSOG forests (FEMAT 1993), and the experience of local taxa experts, FEMAT assessed 1120 species, including 572 fungi, 157 lichens, 106 bryophytes, 124 vascular plants, 102 mollusks, 82 vertebrates, 21 groups of fish, and 15 functional groups of arthropods.

Expert panels of university professors, agency researchers and specialists, and nonagency technical experts evaluated the likelihood of maintaining sufficient habitat on federal lands to sustain viable populations of LSOG-associated species (Meslow et al. 1994). This was the most extensive viability evaluation ever conducted for species in the Pacific Northwest, and possibly the world. The panels assessed management alternatives developed by FEMAT and rated the likelihood of four outcomes relative to habitat conditions on federal lands for each

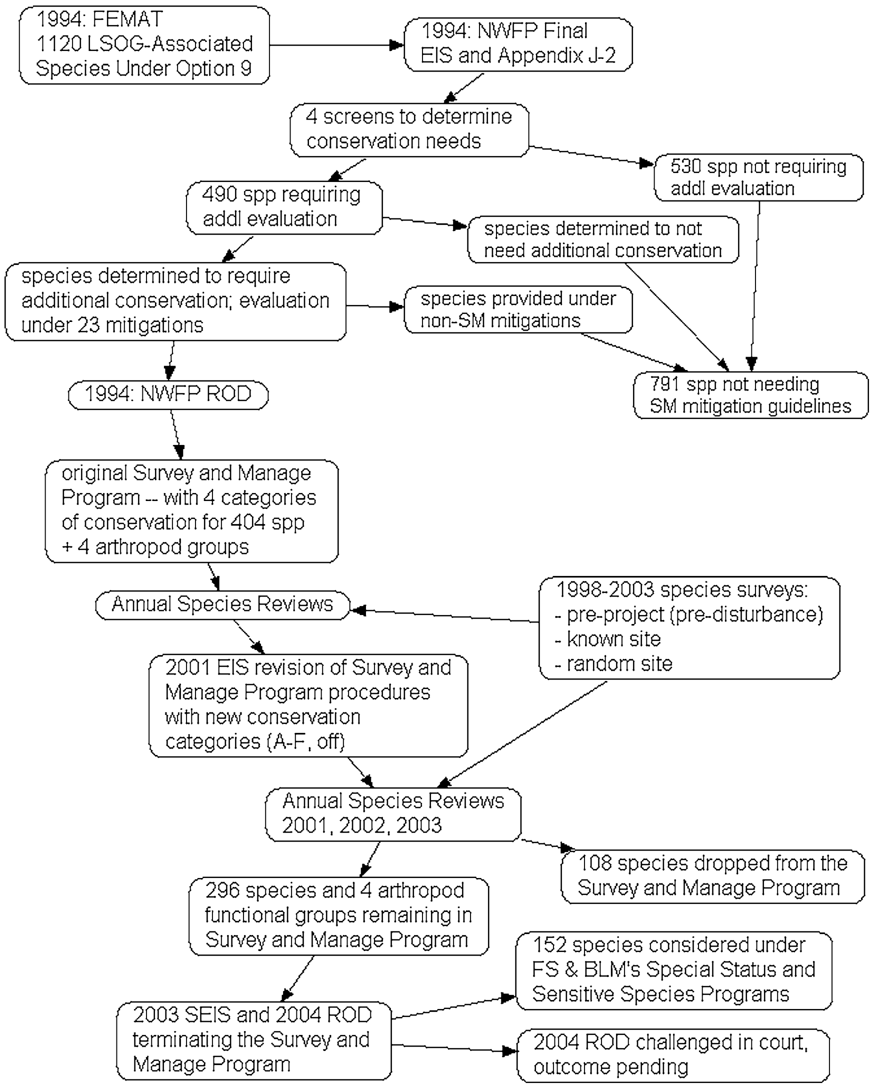

Figure 1. Lineage of administrative programs and U.S. National Environmental Policy Act environmental impact statement (EIS) and record of decision (ROD) documents under the Forest Ecosystem Management Assessment Team (FEMAT), the Northwest Forest Plan (NWFP), and the NWFP's Survey and Manage Program (SM), addressing species closely associated with late-successional and old-growth (LSOG) forests on U.S. Department of Agriculture Forest Service (USFS) and Bureau of Land Management (BLM) administered lands.

species over a 100-year timeframe (FEMAT 1993; Meslow et al. 1994): (1) well-distributed viable populations, (2) viable populations with gaps in distribution, (3) populations restricted to refugia, and (4) risk of extirpation. The species assessments did not constitute quantitative population viability analyses because of lack of data; instead, they entailed a qualitative rating by species experts based on broad-scale maps of land allocations, general forest conditions, and expected results of standards and guidelines under each of nine management alternatives (FEMAT 1993; Meslow et al. 1994). In the FEMAT evaluation, species viability outcomes were influenced by amount of LSOG forest maintained under each alternative; degree of species rarity; geographic distribution of each species; overlap of proposed reserves with known species locations; knowledge of species distribution, rarity, biology, and ecology; and uncertainty of scientific knowledge. Viability of the rarest species (i.e., those with limited geographic distribution and low number of known sites) rated the lowest. Management alternatives that retained lesser amounts of LSOG forest generated the higher levels of risk to species viability. When results were compiled, a number of species and species groups were judged to be at significant risk.

FEMAT examined 23 potential mitigation measures that could be used to benefit the species at greatest risk. A subset of these mitigation measures was adopted into the preferred alternative and record of decision (USDA Forest Service & BLM 1994*b*). The measures included the need to acquire information through field surveys and to manage known sites of the species. This was the origin of the "survey and manage" mitigation standards and guidelines. A site was generally defined as the presence of one or more species included in the SM Program at a location, survey area, or sample plot. The definition of a site varied from a general location to a general area on a topographic map to a fixed-area plot monumented and referenced on the ground. The size of sites also varied among

Table 1. Categories, objectives, and timelines described in the initial 1994 standards and guidelines of the Survey and Manage Program (USDA Forest Service & BLM 1994*b*:C4–C6).

*Categories**	*Objective*	*Timeline*
1-manage known sites	manage sites of species thought to be rare and limited in their distribution	begin immediately, required by 1995
2-survey before ground-disturbing activities (predisturbance surveys)	identify sites of species in project areas and establish managed sites to provide for species persistence	begin protocol development immediately, implement by 1997 for vertebrate species, by 1999 for other species
3-extensive surveys	find new sites and identify high-priority sites for management	surveys under way by 1996
4-general regional surveys	acquire information on species and determine the level of protection necessary to provide for the species persistence	initiate surveys no later than 1996 and complete within 10 years

**Categories were numbered as above in the original standard and guidelines and the status of species was typically referenced by category (e.g., category 1 species).*

taxonomic groups and ranged from several meters across for mollusks to many hectares for the red tree vole (*Arborimus longicaudus*).

Survey and Manage Program Standards and Guidelines

The objectives of the standards and guidelines of the SM Program were to acquire information about species thought to be at risk under the preferred alternative, to discover and protect locations of these species in the plan area, and to assess new information under an adaptive management approach for evaluating needs for conservation and protection of the species. The adaptive management approach also allowed for modifying the schedule of species surveys, changing the management status of a species and removing a species from the SM Program if the species was deemed more secure or common than originally thought. As conceived in 1994, the SM Program initially placed species in four categories of mitigation and survey schedules (Table 1). Many species occurred in more than one category (USDA Forest Service & BLM 1994*b* [their Table C-3]; Table 2).

Implementation: Early Phases 1994–1996

Developing Guiding Documentation

Activities of the SM Program were coordinated initially by a core team of specialists (on part time assignment) from five agencies that met once or twice monthly. Their highest priority was to develop guidelines to manage known occurrence sites (referred to as management recommendations) and protocols for conducting predisturbance surveys. These tasks constituted the first step in the adaptive management process: summarizing current information to guide site management and providing methods to collect additional information to better understand persistence outcomes. Management recommendations on each species provided detailed information on natural history (taxonomy, descriptions, biology, ecology, distribution, habitat, and abundance), current species status (threats, distribution relative to land allocations), and guidelines to maintain suitable habitat for species persistence at the site scale and suggested research and information needs to better understand species ecology and site management and monitoring needs to address status and trends. Predisturbance survey protocols on category 2 species (Table 2) provided guidance, consistency, and methods

Table 2. Number of species included in the Survey and Manage Program and their distribution in the initial four mitigation categories established in 1994 (USDA Forest Service & BLM 1994*b*).*

Taxon	*Total no. species*	*Category 1*	*Category 2*	*Category 3*	*Category 4*
Fungi	234	147	2	233	20
Lichens	81	30	3	36	45
Mollusks	43	43	43	0	0
Bryophytes	23	20	5	15	3
Vascular plants	17	17	17	0	0
Amphibians	5	2	5	0	0
Mammals	1	0	1	0	0
Arthropods	4 functional groups	0	0	0	4 functional groups
Total	404 + 4 functional groups	259	76	284	69 + 4 functional groups

**Category definitions: 1, manage known sites; 2, survey before ground disturbance; 3, extensive survey; 4, general regional surveys. Some species receive multiple mitigations and so occur in more that one category.*

to field staff, and specified when and where surveys were needed. To reduce time and costs, collecting additional information on habitat features and species abundance was optional and seldom conducted. This management decision reflected the risk attitude of the decision makers and had consequences later during species analyses when valuable habitat and population information was not available from the numerous predisturbance surveys.

Survey Types Required

Predisturbance surveys were a mitigation measure designed to avoid inadvertent loss of sites that might contribute to species persistence. This mitigation was based on the premise that reserves might not fully provide for persistence of some LSOG-associated species and that protecting sites on nonreserve matrix lands was needed. Predisturbance surveys were required for 77 category 2 species (Table 2).

Extensive and general regional surveys were required for 354 individual species of fungi, lichens, and bryophytes and for four functional groups of arthropods (category 3 and 4 species; Table 1) for which predisturbance surveys were not practical (i.e., species that were difficult to detect such as fungi). Surveys were to be implemented by 1996 and completed in 10 years. This daunting task of surveying for 345 rare species over the 9.7-million-ha plan area was the key approach to gathering new information and reducing uncertainty regarding conservation needs of each species and a way to determine species distributions within the plan area. Slow progress was made on these regional surveys because of limited budgets and resources.

Predisturbance surveys of the various taxonomic groups determined whether a species was present in a proposed project area. Survey protocols were developed to reduce the likelihood of nondetection when a species was present, and multiple site visits were required for some taxa. In general predisturbance surveys were conducted where the target species was known in the project area or vicinity, the project area was within the known or suspected range and habitat of the target species, and the proposed activity had the potential to adversely affect the species or its habitat. Most of these surveys were not plot based but covered the proposed project area. Transects were used for locating amphibians and red tree voles, and quadrats were used for locating aquatic mollusks. Required data included species presence or nondetection, area surveyed, species location, and general habitat data.

The predisturbance survey mitigation became the most costly and contentious aspect of the SM Program. After a few years of predisturbance surveys, a small number of species under the SM Program proved more common than originally concluded in the FEMAT analysis, occurring at several thousands of sites primarily in nonreserve matrix land. Field managers typically chose to stall or cancel activities at these sites, which greatly affected planned timber harvest for the Northwest Forest Plan. The outcomes of these decisions placed the SM Program at the heart of the controversy surrounding the lack of timber production under the plan.

The agencies failed to meet some deadlines for completing predisturbance survey requirements and were subsequently sued and required to conduct an environmental assessment to extend the deadline 1 year as part of the settlement. This action, together with the growing expense of predisturbance surveys and inability to meet timber targets, led regional executives to decide that after 4 difficult years of implementation the SM Program needed significant review, better resources, new vision, and regional leadership.

Adaptive Changes: Environmental Impact Statement and 2001 Record of Decision

The entire SM Program was reassessed and redesigned to organize and expedite the adaptive management process and to reduce confusion around the original standards and guidelines. The new SM Program standards and guidelines (USDA Forest Service & BLM 2001) focused on better-defined categories of mitigation, strategic survey measures to more effectively gain new information, and an annual species review process to assess species status and make decisions.

Six new species categories were developed that clearly described the conservation status and required mitigation for each species. The categories were based on species rarity, predisturbance survey practicality, and sufficiency of information to determine whether the species warranted protection (Table 3). All six categories required strategic surveys that were intended to focus survey effort in late-successional reserves.

Molina et al. (2003) developed a strategic survey framework that described an iterative adaptive management process for acquiring data and managing species. The framework called for evaluating and prioritizing information needs on all species, designing and implementing strategic surveys, and analyzing survey results relevant to species and habitat management. This approach addressed high-priority questions, especially distribution in reserves or association with LSOG forest habitat. Field surveys ranged from broad-scale, statistically based sampling to gather information on multiple species over the entire plan area to surveys at known sites to gather data on individual species presence, abundance, and habitats. Other activities included conducting species-specific research studies and developing habitat models designed to map potential habitat, predict species presence, and guide surveys (Table 4). The strategic survey effort was expected to take several years to complete. To date, few results of strategic surveys have been published (Niwa & Peck 2002; Dunk et al. 2004; Edwards et al. 2004; Lesher

Table 3. Species categories in the Survey and Manage Program based on species characteristics, survey practicality, and species status, as redefined in the 2001 record of decision (USDA Forest Service & BLM 2001).[a]

Relative rarity	*Predisturbance surveys practical[b]*	*Predisturbance surveys not practical*	*Status undetermined*
Rare	category A (57); manage all known sites, conduct predisturbance surveys	category B (222); manage all known sites, no predisturbance surveys	category E (22); manage all known sites, no predisturbance surveys
Uncommon	category C (10); manage all known sites, conduct predisturbance surveys, select high-priority sites for management	category D (14); manage all known sites, no predisturbance surveys, select high-priority sites for management	category F (21); known sites not managed, no predisturbance surveys

[a]Number of species in each category in parentheses. All species receive strategic surveys.
[b]Surveys are practical if characteristics of the species (such as size, regular fruiting) and identifying features result in being able to reliably locate the species if it is present within one or two field seasons and with a reasonable level of effort (USDA Forest Service & BLM 2001).

2005; Peck & Niwa 2005) and the majority exist as agency documents.

The annual species review evaluated the conservation status of LSOG species under the SM Program. Teams of taxa experts compiled data on species selected for review and presented the information to panels of managers and biologists. The panels reviewed the information and suggested changes in the conservation status of individual species to agency decision makers. Unlike the FEMAT panel process in which species experts assigned viability ratings as outcomes, the annual species review process documented the new ecological and survey data on each species and how such data were explicitly used in expert-panel evaluations to determine the appropriate conservation category for each species. New data included number of sites, distribution in reserve and nonreserve lands, habitat and forest-age associations, and local abundance. The annual species reviews and the panels' use of decision models were successful as an adaptive management process that annually evaluated scientific data on selected species. The annual species review process opened the "black box" to specifically explain how species data were used in the decision process. The process also clearly displayed the types and degrees of scientific uncertainty about each species and the overall levels of decision-making uncertainty of interpreting the data within the mandatory guidelines (Marcot & Molina 2006).

Table 4. Descriptions of survey types, objectives, and plot designs as implemented under the strategic survey framework of the Survey and Manage Program.[a]

Survey type	*Survey objective[b]*	*Taxa group*	*Plot-based survey (plot size, ha)*
Random grid	stratified random sample to provide abundance estimates, test hypotheses of association with LSOG forests and reserve-land allocations	fungi, bryophytes, lichens, vascular plants, mollusks and red tree vole	yes (varied: 0.01, hypogeous fungi; 0.1, epigeous fungi; 0.2, bryophytes, lichens, and vascular plants; 1.0, mollusks)
Known site	document accurate locations of target species; install permanent monitoring plot; collect detailed habitat, site, and local population information	fungi, bryophytes, lichens, vascular plants, mollusks	yes (0.04)
Habitat model validation	stratified random sample to test hypotheses on accuracy of habitat model, occurrence of target species in habitat strata, association with LSOG and reserve land allocations	lichens, vascular plants	yes; (0.81)
Purposive surveys	relocate historic locations, find new locations of target species	fungi, lichens, bryophytes, vascular plants, mollusks, amphibians	typically not
Research projects	address specific questions and objectives for target species	various taxa groups, including arthropods, fungi, lichens, mollusks, red tree vole, amphibians	depends on specific survey[c]
Other surveys	address specific questions and objectives for target species	red tree vole, amphibians	depends on specific survey

[a]See Molina et al. (2003) for background on the selection and use of strategic surveys. Details of specific surveys are available in the 2003–2004 Strategic Survey Implementation Guide (http://www.or.blm.gov/surveyandmanage/strategicsurveyguides/2003/2003_ss_implementation_guide.pdf, accessed November 2005).
[b]Abbreviation: LSOG, late-successional old growth.
[c]A variety of research projects were conducted. Many used plot-based experimental designs and others used transect and timed searches.

Examples of Survey Results and Adaptive Management Decisions

Data Accumulation

The agencies combined data from extensive searches in herbaria and museums on known locations of the original 404 species with data from agency files, individuals, and publications to develop the first "known site database" for the SM Program. When assembled in early 1998, the database had approximately 19,000 records; half were lichens from a Forest Service regional air-quality study. By January 2005 the number increased to 68,151 records. Records for some taxa doubled, and increased approximately fourfold for fungi, fivefold for bryophytes, and nearly fourfold for mollusks, constituting an unprecedented data set on these poorly known taxa (Fig. 2). The major increase in known sites was from predisturbance surveys that began in 1998 on taxa other than amphibians. By 2004, 79% of all records were from predisturbance surveys. Given that 50,690 sites were found primarily in predisturbance surveys in matrix lands where timber harvest activities were to occur, the conflict between protecting many of these sites and providing for timber harvest became evident.

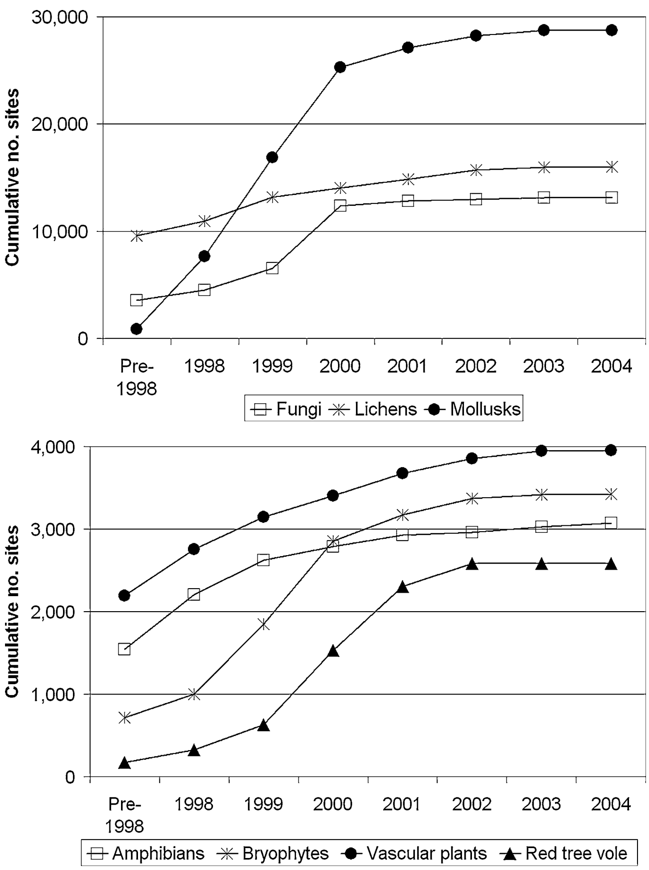

Figure 2. Cumulative number of sites located from all surveys on all land allocations (reserves and matrix lands) by taxonomic group and year. Substantial progress was made in locating sites, particularly between 1998 and 2000.

Understanding Species Rarity

Within the NWFP area, poorly known species listed under the SM Program may be rare, sparse, or elusive (i.e., rare everywhere with low number of sites, more widely distributed but sparse everywhere, or more numerous but elusive with low detectability in field surveys, respectively; Thompson 2004). Part of the SM Program was designed to differentiate among these conditions, develop and implement reliable field survey protocols to account for species detectability, and assign appropriate conservation categories to each species. Field data consisted of a combination of locations known from past surveys or studies and newly discovered occurrences of each species. When species were newly discovered, however, data were seldom collected on species abundance at the site, so estimates of local population size were not available to factor into rarity determinations. Regardless, the extent and expense of the field surveys were unprecedented.

Two patterns emerged from the field surveys (Fig. 3). First, most species under the SM Program were encountered very infrequently, confirming one of the original assumptions of the FEMAT panelists. For example, 53% of 407 species surveyed were known from 20 or fewer sites, 41% from 10 or fewer sites, and 29% from 5 or fewer sites. Yet species from 20 or fewer sites accounted for only 2% of the total records. Second, a small number of species were found frequently. About 6% of all species accounted for 71% of the total records, with 17 species having more than 1,000 records each (2 mollusk species accounted for 17,000 records). These frequency patterns held across all taxonomic groups surveyed. The SM Program was successful in finding and protecting known sites for truly rare species, thus meeting an original objective. The small percentage of species that turned out not to be as infrequent as originally believed, however, had the greatest effect on not meeting timber-harvest objectives under the Northwest Forest Plan. The SM Program was slow to remove many of those frequently encountered species from the program or to protect a small subset of high-priority sites for them as specified in the standards and guidelines.

Landscape-Scale Sampling and Association with LSOG Forests and Reserves

Most species shared two important unknowns: Were they associated with LSOG forests? and How well did the reserve-land allocations provide for their persistence? Known sites for species within each taxonomic class occurred in both reserve and nonreserve lands (Fig. 4). The number was greater in nonreserve land, most likely because of the substantially greater number of predisturbance surveys conducted in nonreserve matrix lands.

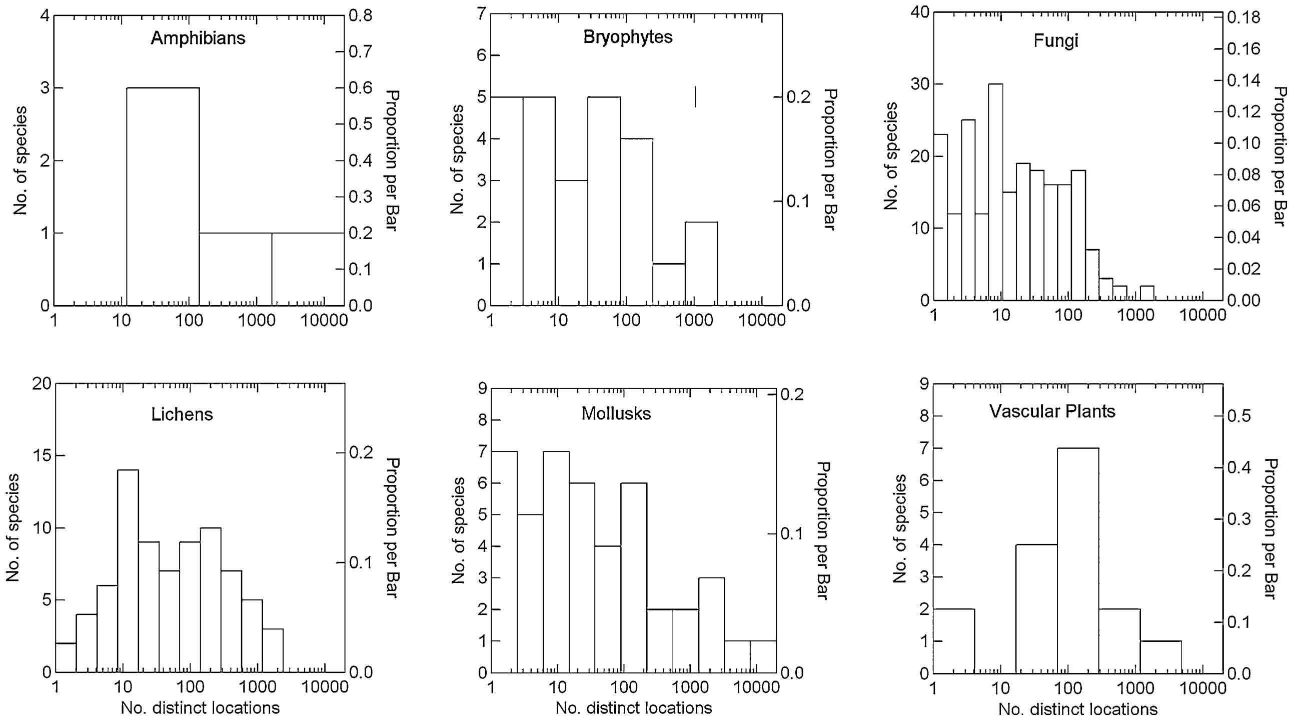

Figure 3. Species detection distributions of the number of distinct locations of species of the Survey and Manage Program (sites located through various surveys) within the Northwest Forest Plan area by taxonomic group, excluding mammals (for which the database was not available for this summary). The x-axis is $\log_{10}$ scale.

Hence surveys were needed in reserve-land allocations to determine whether reserves provide for species persistence. Also, species not associated with LSOG forests could be removed from the SM Program.

Managers requested a sampling design that could be used to address species rarity and habitat distribution throughout the plan area. To meet this need, a group of scientists and statisticians designed a "random-grid survey" that used a random selection of grid points already established over the entire plan area for regional and national timber inventories (Molina et al. 2003). Sample-population grid points were either 2.7 or 5.5 km apart, depending on location. Grid points consisted of 1-ha circular plots; total area surveyed at each grid point, however, ranged from 0.01 ha for hypogeous fungi to 1 ha for mollusks (Table 4). The survey design stratified random-grid sampling points into LSOG and non-LSOG forests and into reserve and nonreserve land allocations. Approximately 750 random-grid points from a population of 3959 points were surveyed over 3 years for most species at a total cost of more than $8 million.

Approximately 3000 new site records were added from the random-grid survey on 179 species, roughly one-third of them lichens and another third fungi. Results of the random-grid survey showed, however, that the greatest number of species occurred on 10 or fewer plots, one-third occurred on only 1 or 2 plots, and 40% of the species were not detected on any plot. These results confirmed

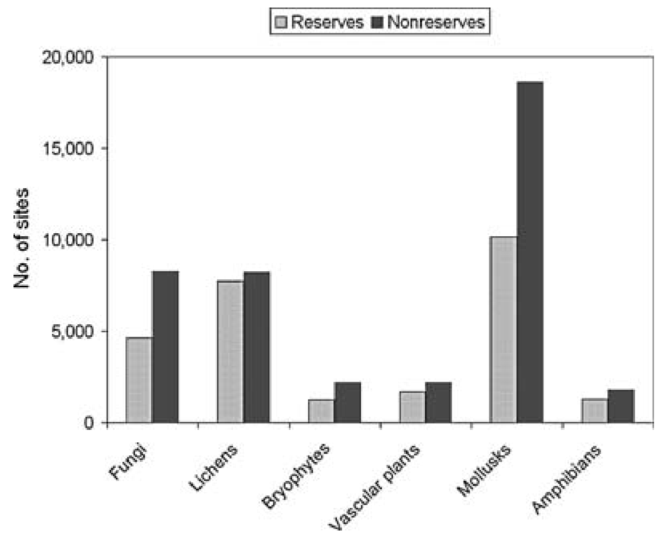

*Figure 4. Number of known sites of species of the Survey and Manage Program, located through various surveys, by reserve and nonreserve land allocations on BLM and USFS lands within the Northwest Forest Plan area. Reserves include adaptive management areas, administratively or congressionally withdrawn areas, and late-successional reserves. Nonreserve lands include riparian reserves (not separable in the database) and matrix lands as described in the plan (USDA Forest Service & BLM 1994*b*).*

expectations by Edwards et al. (2004) that this broad-scale type of random grid survey was not likely to detect extremely infrequent species. Several species detected frequently on the random grid had already been removed from the SM Program and others were suspected of not being rare. The random-grid survey also extended the known geographic distributions of several species.

The ability to predict LSOG forest or reserve land association, however, proved difficult. Sufficient data for statistical analysis of these associations were gathered on only 108 species. Based on data from the random-grid sample, most species in the SM Program (73%, or 286 of the 394 species in this study) were too rare or difficult to detect to quantify associations with reserve land or LSOG forest. Even among the 108 species, only 41 had 10 or more detections.

Findings suggested that only one species (a lichen) was significantly or marginally ($p < 0.10$) associated with reserve land and two species (two lichens) were associated with matrix lands (M. Turley, personal communication; Cochran-Mantel-Haenzel and Fisher's exact statistics; test values and n varied among species). Twenty-one species (3 bryophytes, 2 fungi, 16 lichens) were significantly or marginally associated with LSOG forest conditions, and 2 species (1 lichen, 1 mollusk) were associated with non-LSOG lands. Overall, about one-third of all testable species showed association with LSOG forest, but only one species was associated with reserves. Lack of association with reserves should not necessarily be construed as the failure of the reserves to provide important habitat for species persistence, particularly for those species that do show association with LSOG forest. Late-successional and old-growth forests currently occur in both reserve and nonreserve lands. It will take hundreds of years for LSOG forest to regrow within reserves, and the landscape also will be subject to perturbations such as fire. It is unknown whether there will be bottlenecks in species' recovery or persistence over such long-term dynamic changes.

Whether the late-successional reserves alone currently protect all species in the SM Program cannot be determined by the results of the random-grid study, and no temporal monitoring has been done on their persistence. Where, however, it can be shown over time that late-successional reserves (and the increasingly greater percentage of LSOG forest within the reserves) provide for species in the SM Program, any additional mitigation measures for those species, such as protection of sites in the matrix lands, most likely can be dropped.

Legal Challenges, Politics, and Final Disposition of the Survey and Manage Program

Given that the Northwest Forest Plan grew out of frustrating years of litigation, it was not surprising that concerned members of the public would scrutinize the SM Program. By the time the 2001 reorganization of the SM Program was complete, there was growing controversy surrounding the program. The timber industry was increasingly frustrated by low levels of timber harvest due in part to protecting species sites in matrix land. Environmental groups were concerned about potential loss of rare species if the mitigation was weakened. In November 2001, both groups sued the federal government over aspects of the 2001 record of decision.

In response to the 2001 lawsuit brought by the timber industry, the U.S. Departments of Agriculture and Interior settled and agreed to conduct a new analysis of the SM Program. The resulting analysis and record of decision (USDA Forest Service & BLM 2004*a*, 2004*b*) terminated the SM Program and moved management of 152 of the remaining 296 species into the agencies' existing sensitive species and special-status species programs (Fig. 1). In 2004 termination of the SM Program prompted another lawsuit from environmental groups. In August 2005, the court found in favor of the plaintiffs on several points, including inconsistencies with previous analyses on how well the Northwest Forest Plan provided for species persistence. Court proceedings and final disposition of the SM Program are pending.

The future of species formerly listed in the SM Program may also be affected by other aspects of the Northwest Forest Plan that are currently in flux. The agencies are conducting a review of the first 10 years of monitoring and research under the Northwest Forest Plan and considering modifications to the plan. In 2004 the Bureau of Land Management settled another lawsuit that requires them to consider removing reserves as established in the Northwest Forest Plan through a plan revision process. Those plan revisions are currently under development, and it remains unknown whether the final management strategies will exclude reserve designations. Thus the effect of this settlement agreement on the conservation of species formerly under the SM Program cannot be ascertained until the plans are complete and effects analyses on species are conducted. These types of litigations and controversies exemplify the complex nature of balancing diverse public views on best use and management of public forests in the United States.

Lessons Learned and Use of Findings Elsewhere

Although mired in complexity and controversy, the SM Program made important gains in practical management experience for conserving rare, little-known taxa at a regional scale. We reflect on a few key science and management aspects of the SM Program that warrant consideration for conservation programs elsewhere (see Marcot & Molina [2006] for management implications).

Fine- and Coarse-Filter Considerations Revisited

Evaluating the status and persistence of the species in the SM Program can help test some of the assumptions of the coarse-filter approach to management of rare or little-known LSOG species. Results of several regional assessments (FEMAT 1993; Thomas et al. 1993) initially suggested that ensuring the persistence of a set of rare or little-known species associated with LSOG forest might require explicitly including their microhabitat conditions and specific locations under Northwest Forest Plan management guidelines instead of relying only on providing habitat for a management indicator species (i.e., Northern Spotted Owl).

Findings of the random-grid survey suggest that LSOG forest is important for at least a third of the less rare species in the SM Program that were statistically evaluated, and likely other, more rare species as well. There is little evidence from the random-grid survey, however, that at present the late-successional reserves provide for these particular species, although that picture might change as LSOG forest is further restored within late-successional reserves and lost in the matrix. At present, given the number of locations of the more rare species outside the late-successional reserves, it is not clear that the reserves alone suffice to provide habitat and geographic protection for all rare and poorly known LSOG-associated species in the Pacific Northwest. The key questions remaining are: How much macrohabitat (LSOG forest) and microhabitat components (LSOG legacies such as large snags, large green trees, and large down wood in matrix settings) are needed, and where should they occur to provide for species persistence? Do the reserve boundaries, including riparian reserves and old-forest restoration sites in the matrix, encompass adequate numbers and distributions of sites belonging to these species to ensure their persistence? Will key habitats be lost from management activities and natural disturbance processes over the life of the Northwest Forest Plan, and will the species be able to survive through any bottleneck periods? Most of these questions cannot be answered at present because little temporal monitoring or basic life-history studies have been conducted on the species or other aspects of LSOG forest biodiversity.

Thus, if the management objective is to ensure persistence of all such species to the best of our scientific knowledge, then there may be a need to provide at least some continued fine-filter evaluation and management guidelines for site survey and protection, and for LSOG components, in the managed forest matrix for at least some of the more rare and poorly known species. Combining fine-filter elements of locations and microhabitat conditions of selected species with coarse-filter elements such as providing continuity of natural system conditions and dynamics may provide complementary layers of protection (New 1997; Kintsch & Urban 2002; Noss et al. 2002); the species approaches may protect existing sites and known populations and the system approaches are intended to best maintain undiscovered sites and as-yet-unknown requirements.

This could be accomplished efficiently with a three-tiered approach (Hunter 2005): (1) fine-filter management (addresses individually those LSOG species that are threatened, endangered, and the rarest or most elusive, and for which life history is poorly known or whose known locations mostly fall outside reserves); (2) mesoscale filter management (addresses other LSOG species in groups, such as by similar substrate and microhabitat associations, occurrence by LSOG patch size, and ecological function); and (3) coarse-filter management (conserves or restores landscape patterns and ecosystem or disturbance dynamics within specified ranges of natural variation). The mesoscale filter in particular could entail providing some patches, substrates, and components of LSOG outside reserves in the managed forest matrix. Overall, joint guidelines for individual species, species groups, and system dynamics would be likely to provide an efficient and useful synthesis to help ensure persistence of LSOG species and their habitat and environmental requirements without having to address every species individually.

Survey Strategies

The adaptive nature of the SM Program was supported by new information collected via field surveys and reaffirming or changing management categories of species. From the sheer number of known site records obtained after 10 years of surveys, efforts appear remarkably effective. New data have reduced uncertainty and persistence concerns for more than 100 species, which were subsequently removed from the SM Program. Survey data are biased toward matrix lands, however, because of the extensive predisturbance survey effort. Data from these surveys are often limited in value because most records exist only as location data, with little information on habitat attributes or absence of target species. Program changes in 2001 emphasized strategic surveys over predisturbance surveys and attempted to rectify some of these initial biases by targeting reserve lands and LSOG forest habitat.

Several lessons emerge regarding efficacy of survey approaches for regional-scale conservation programs. Most important is a clear vision of specifically what information is needed at various spatial scales to make the best science-based decisions to meet conservation objectives. Predisturbance surveys at specific sites can be effective if there are reasons to suspect that the species occurs in the project area. When species habitat and distribution are unknown or highly uncertain, however, resources may be better focused on landscape surveys to learn more about the species' distributions and habitat requirements. If many species of concern are suspected of occurring in the planning area, surveys of multiple species can effectively gather initial information. Based on findings from these surveys, smaller-scale surveys could then target potential habitat, particularly through the use of models of species-habitat relations (Molina et al. 2003; Lesher 2005). It is also important to consider the strengths and weaknesses of random and nonrandom survey approaches to locate rare, little-known species (Edwards et al. 2004). Regardless of approaches selected, a process to evaluate survey effectiveness and address needed changes is an important part the planning cycle.

Adaptive Management Decisions

Adaptive management often remains an elusive goal in ecosystem management (Stankey et al. 2003). Thus, refinement of the SM Program through the 2001 guidelines, including the annual species reviews and strategic surveys, should be recognized as a major accomplishment. Strategic surveys and annual species reviews demonstrated the ability to gather, analyze, and use new information to better inform decisions on species status and management. Key to their success was designing a process first to ask priority questions on information needs and then to bring the information gained into the decision-making process. The annual species reviews provided detailed analyses on species attributes and documented the uncertainty in interpretations. Use of decision-support models helped clarify the role of scientific information in the species evaluation guidelines and how managers dealt with uncertainties. Learning and decision processes need to be designed as part of the original vision of the program.

Partnerships

Implementing a successful species conservation program of the size and complexity described required strong collaboration, shared resources, and leadership. The ability to work in an integrated fashion among six federal agencies was perhaps one of the most difficult challenges successfully navigated by the SM Program. These agencies committed resources and personnel from throughout the region, at times involving more than 60 specialists, including field biologists, ecologists, researchers, managers, and data analysts, to work at the regional scale, with dozens more involved at field locations. As the program matured, the key to efficiency and effectiveness was the hiring of permanent staff in 2001 and vision and leadership provided by regional managers. Collaboration was crucial to clearly developing the short- and long-term visions for the program, including how decisions will be made in an interagency setting.

Conclusions

Whether perceived as a visionary conservation program or simply an experiment of unbridled management complexity, the SM Program accrued important gains in knowledge about rare and little-known species. It addressed and considerably reduced uncertainty about conservation of a number of species and developed new methods of species inventory that will prove valuable in future management planning and implementation at many scales. The SM Program, however, was not carried through to completion because of changes in land-management philosophy. The ongoing litigation regarding termination of the SM program and potential changes to the Northwest Forest Plan cast further uncertainty on how the original goal of maintaining persistence of LSOG-associated species will be met and measured. The outcomes, controversies, and management frustrations that were cast on the SM Program exemplify the inherent difficulties in balancing broad, regional conservation goals with the other social and economic goals of the Northwest Forest Plan. Defining acceptable trade-offs to reach that balance and developing practical, on-the-ground conservation solutions remain challenges for the science and management communities. Lessons learned from the SM program provide a valuable biological and managerial reference to benefit future discussion on meeting those challenges.

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