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Strategic Survey Framework for the Northwest Forest Plan Survey and Manage Program

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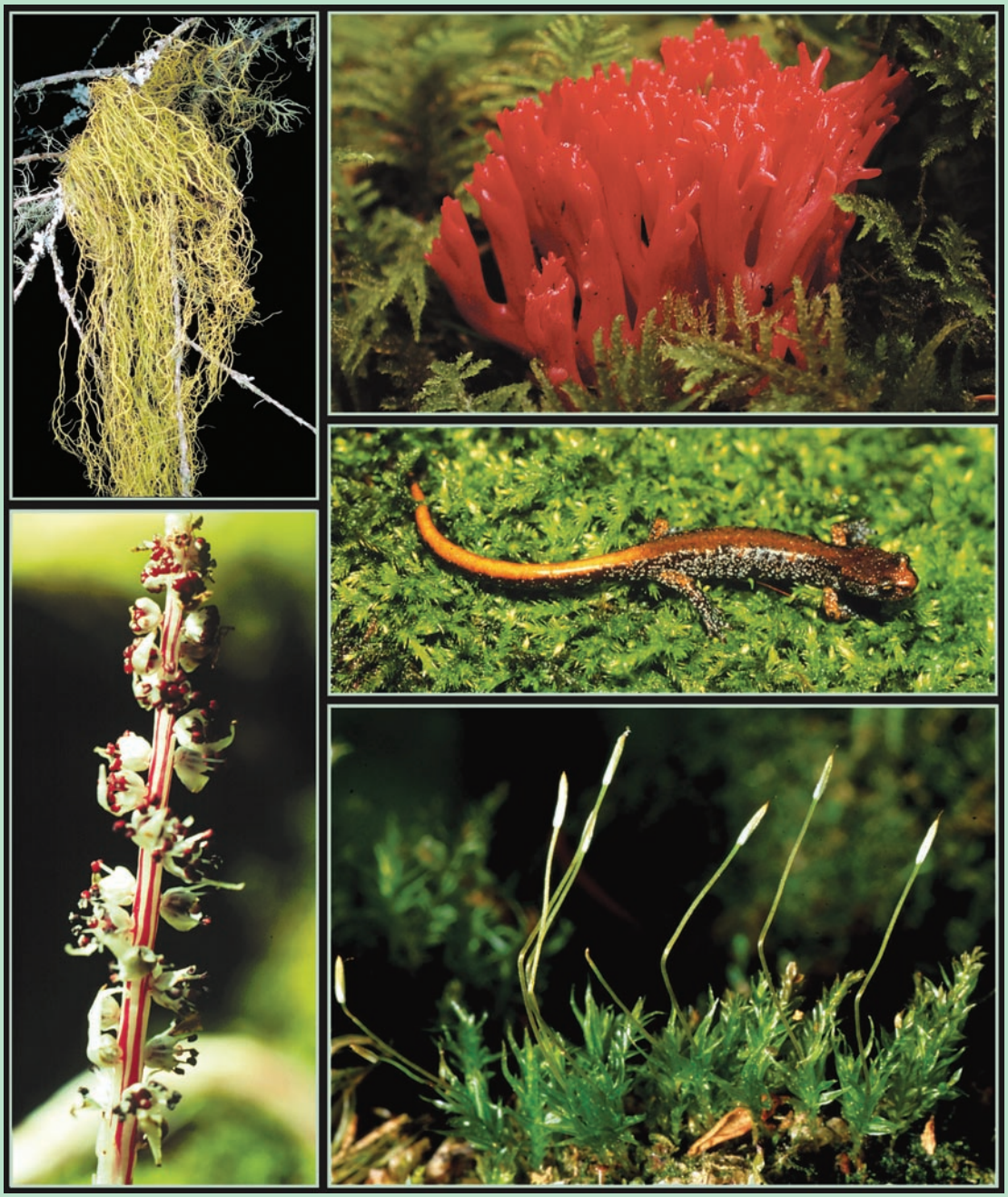

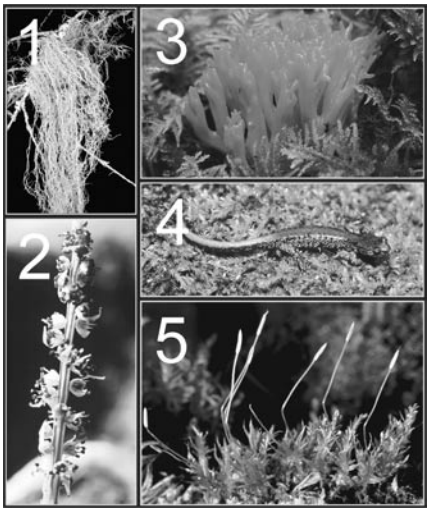

Cover—The survey and manage mitigation of the Northwest Forest Plan provides protection for taxonomically and structurally diverse species in eight taxa groups: amphibians, arthropods, bryophytes, fungi, lichens, mammals, mollusks, and vascular plants. Five species on the cover illustrate the diversity in form: (1) *Bryoria tortuosa* (photo courtesy of Stephen Sharnoff), (2) *Allotropa virgata* (photo courtesy of Dan Luoma), (3) *Ramaria araiospora* (photo by Dan Powell), (4) *Plethodon vandykei* (photo courtesy of William Leonard), and (5) *Tetraphis geniculata* (photo courtesy of Martin Hutten).

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Abstract

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This document outlines an iterative process for assessing the information needs for all Northwest Forest Plan (NWFP) survey and manage species, designing and implementing strategic surveys (including field surveys and other information-gathering processes), and analyzing that information for use in the NWFP annual species review and adaptive-management processes. The framework outlines a series of steps that provide guidance for development of (1) priority information needs, (2) evaluation and selection of information-gathering approaches, (3) implementation of annual work plans, and (4) management, reporting, and transfer of information to the annual species review process. Approaches include design-based statistical surveys, modeling, expert searches, and research that are anticipated to be used singly or in combination to address the priority survey and manage questions and information needs.

Keywords: Survey, conservation, biodiversity, species persistence, late-seral old-growth forests.

Summary

In 1994, the USDA Forest Service and USDI Bureau of Land Management adopted standards and guidelines for the management of habitat for late-successional old-growth (LSOG) forest-associated species within the range of the northern spotted owl (*Strix occidentalis*), commonly known as the Northwest Forest Plan (NWFP). The survey and manage guidelines of the 1994 record of decision (ROD) (USDA and USDI 1994) provided an adaptive-management process for acquiring information and managing rare and uncommon, poorly understood old-growth-forest-associated species. That process is based on managing species and their habitats consistent with the best current information, and utilizing a comprehensive program of information gathering, analysis, and interpretation to guide management actions while providing likelihood of persistence for LSOG forest-related species.

A supplemental environmental impact statement to the NWFP was prepared and a ROD signed in 2001 (USDA and USDI 2001). That ROD updated the survey and manage standards and guidelines, clarified and improved the survey and manage adaptive-management processes, and provided direction for preparing management recommendations and survey protocols, and for conducting strategic surveys. It also established a process and criteria for an annual review of new species information to determine when a species should be assigned to different categories, or added to, or removed from, survey and manage standards and guidelines.

With the growth of the survey and manage program, the ROD (USDA and USDI 2001) called for a process document (*Strategic Survey Framework*) to provide guidance for achieving the primary program goals. This document outlines an iterative process for assessing the information needs for all survey and manage species, designing and implementing strategic surveys (including field surveys and other information-gathering processes), and analyzing that information for use in the annual species review and NWFP adaptive-management processes. The framework describes a series of tasks and processes for the development of the relevant information. The ROD (USDA and USDI 2001) and the framework also provide guidelines for determining when strategic surveys are complete. The framework outlines a series of steps that provide guidance on (1) developing priority information needs, (2) evaluating and selecting information-gathering approaches, (3) implementing annual work plans, and (4) managing, reporting, and transferring information to the annual species review process. Approaches include design-based statistical surveys, modeling, expert searches, and research that can be used singly or in combination to address the priority survey and manage questions and information needs. Links to adaptive management through the annual species reviews, species information-needs analysis, and *Strategic Survey Implementation Guide* are described.

Conducting strategic surveys at the scale of the NWFP for nearly 400 species is unprecedented in scope and complexity. The *Strategic Survey Framework* outlines a program to help federal land managers obtain information about the distribution and occurrence of rare and uncommon, poorly understood old-growth-forest-associated species. When combined with the adaptive-management process, this information will contribute to achieving the NWFP goals and objectives, including providing for the desired level of protection for survey and manage species.

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Introduction

In 1994, the USDA Forest Service and USDI Bureau of Land Management adopted standards and guidelines for the management of habitat for late-successional old-growth (LSOG) forest-associated species within the range of the northern spotted owl (*Strix occidentalis*), commonly known as the Northwest Forest Plan (NWFP). The key elements of the NWFP are the system of reserves (with focus on maintenance of late-successional habitats), the aquatic conservation strategy, and various standards and guidelines affecting each of seven different land allocations. Also, mitigation measures were included for management of about 400 rare and locally restricted species, collectively known as the "survey and manage" program. The survey and manage guidelines of the NWFP record of decision (ROD) (USDA and USDI 1994) provide an adaptive-management process for managing rare and uncommon, poorly understood old-growth-forest-associated species. The adaptive-management process is based on managing species and their habitats consistent with the best current information, and utilizing a comprehensive program of information gathering, analysis, and interpretation to guide management actions while providing for the likelihood of persistence for LSOG forest-associated species.

Beginning in 1999, the Forest Service and Bureau of Land Management undertook an effort to amend the survey and manage portion of the NWFP by adopting new standards and guidelines for that section. It was anticipated that this effort would make it possible for the agencies to more efficiently provide the level of species protection intended in the NWFP. A ROD for the supplemental environmental impact statement was signed in January 2001 (USDA and USDI 2001).

The ROD (USDA and USDI 2001) updated the standards and guidelines, clarified and improved the survey and manage adaptive-management processes, and provided direction for preparing management recommendations and survey protocols and for conducting strategic surveys. It also provided a process and criteria for an annual review of new species information to determine when species should be assigned to different mitigation categories,[1] or added to, or removed from, survey and manage lists.

The ROD (USDA and USDI 2001) required that strategic surveys be conducted for all survey and manage species. Strategic surveys are intended to contribute to meeting the NWFP goal of maintaining species persistence by efficiently and effectively acquiring needed information regarding species' range, distribution, habitat use, and abundance. Strategic surveys also can help refine habitat descriptions and define geographic range and information needs for future surveys and provide important information on population status, life history, habitat use, and site management. This information will address fundamental questions such as:

- Is the species closely associated with late-successional forests?
- Is there a concern for persistence?

[1] Survey and manage species are placed into one of six mitigation categories: A, B, C, D, E, or F. Categories are defined based on degree of species rarity, survey practicality or need, and sufficiency of information. Several criteria determine these characteristics. The appendix lists these criteria and the mitigation measures applied to each category. A full description of the categories and their mitigation can be found in the ROD (USDA and USDI 2001: 6–14).

- Is the species rare or uncommon?
- What is the appropriate management for the species?
- Do the reserve land allocations and other standards and guidelines of the NWFP provide a reasonable assurance of species persistence?

Responsibility for the design and coordination of strategic surveys rests with the regional offices of the Forest Service and state offices of the Bureau of Land Management, in collaboration with the U.S. Fish and Wildlife Service and research agencies. A regional survey and manage team has been established to provide oversight and direction for implementing the NWFP survey and manage program. Responsibility for field implementation and followup actions may be delegated to administrative units. The research agencies will be cooperators in developing scientifically sound survey protocols and providing biological and analytical expertise. The research branch of the Forest Service will take the lead in developing and implementing research projects that address strategic survey issues.

Framework

The *Strategic Survey Framework*, a process document, outlines an iterative process for assessing the information needs for all survey and manage species, designing and implementing strategic surveys (including field surveys and other information-gathering processes), and analyzing that information for relevance to species and habitat management. The framework sets the context for development of the *Strategic Survey Implementation Guide* (SSIG), which will outline the priorities and annual work plan for implementing strategic surveys across the NWFP area. The primary components of the framework and their interactions are shown in figure 1.

A complete strategic survey iteration provides information for the adaptive-management process, including the NWFP annual species review process and species management. The need for future strategic surveys is determined based on an assessment of available data and information and the identification of species information needs. A brief description of the components of the framework and the processes connecting the components follow. We begin with the species information-needs analysis because that is the initial and most crucial process in the framework for defining the underlying questions and information needed to develop a science-based understanding of species-persistence concerns.

Species Information-Needs Analysis

Outcomes and objectives—The final outcome of the species information-needs analysis provides information for subsequent steps described in the framework and the development of strategic surveys. The objectives of the species information-needs analysis are to (1) identify pertinent species persistence and management questions, (2) summarize current knowledge, (3) evaluate the ability to address species-specific questions and highlight significant knowledge gaps, and (4) identify the information needed to address identified questions. Information needs will differ among species because of differences in rarity, distribution, habitat requirements, and persistence and management concerns, as well as the amount and quality of information available for a species.

The species information-needs analysis identifies and updates the persistence and management questions for each species and is guided by the results of the annual species review process. The analysis summarizes the information available to address the identified questions for each species. Assessment of the available information and areas of insufficient information helps identify information needed to address the

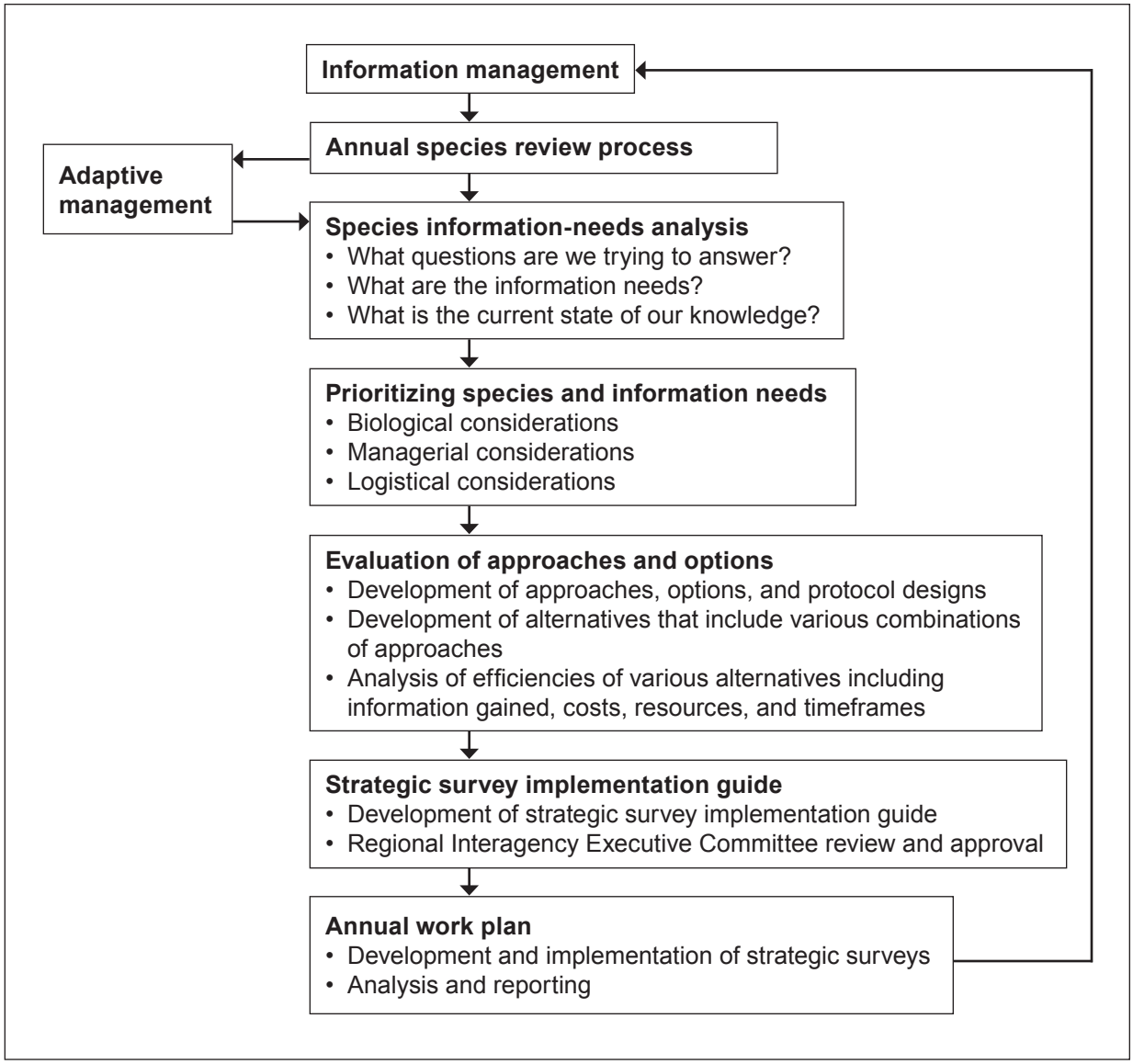

Figure 1—Strategic survey framework.

relevant questions. This listing of information needs provides input to a process that prioritizes information needs across all survey and manage species, as well as within individual species. The ROD (USDA and USDI 2001) requires that this information be included, and periodically updated, in the SSIG. The priority information needs form the foundation for the annual work plan for conducting strategic surveys and other information-gathering tasks.

Three primary questions drive the information needed for a species (ROD) (USDA and USDI 2001):

1. What are the primary concerns for species persistence?

2. How do we manage species and habitats to ensure species persistence?

3. Does the species need the survey and manage standards and guidelines to provide a reasonable assurance of persistence?

These three questions are subdivided into several specific questions that focus on species rarity, range and habitat associations, persistence and management concerns, and information needed for site management (see next section).

Analysis process—The species information-needs analysis process involves two steps: (1) analyze available information and (2) summarize species status, questions, and strategic information needs. Step 1 involves analyzing relevant information for the specific questions (noted in the "Primary Questions and Information Needs Addressed by Strategic Surveys" section) and then summarizes the findings, reflecting what is known (and not known) and identifying relevant information needed to address the questions. Analysis reports should be brief so that survey planners can quickly and easily compare information needs for each species and among species. Step 2 provides an up-to-date overview of the status for each survey and manage species, including species persistence and management concerns, and relevant information needs. The summary also should prioritize the information needs within each species. When all species are examined, the resulting summary information-needs analysis provides input for prioritizing species and developing the SSIG.

Prioritizing Species and Information Needs

A regional prioritization process determines the level and types of information gathered each year by strategic surveys. Species and information needs are prioritized by using a process that integrates questions and information needs across all survey and manage taxa, based on the results of the species information-needs analysis. Biological and managerial factors, as well as operational and logistical factors are evaluated and used to screen species and to group taxa by similar information needs and priorities. Relative priorities may be assigned to species, species groups, or specific information needs. The results and documentation of the prioritization process are presented in the SSIG, and are used to develop a schedule for implementing strategic surveys aimed at specific species, or acquiring certain types of information within allocated resources and availability of expertise.

There are three types of factors to consider when prioritizing species for strategic surveys: biological, managerial, and operational.

Biological factors—Biological factors address inherent aspects of a species' biology and how these factors relate to persistence concerns or management questions. These include:

- There is much concern for species persistence.
    - The species is thought to be rare
    - The known sites are all historical, or there are no or few recent sites
    - The species has limited distribution
    - There is uncertainty if the species is extant
- There is a great risk for loss of populations (i.e., the species occurs in habitats vulnerable to disturbance from management activities).
- Habitat, site, and species information are needed to develop effective management recommendations.

Managerial factors—Information may contribute to increased management efficiency. If strategic surveys provide information that may lead to a species changing categories or being removed from the survey and manage list, or increasing efficiencies in preproject surveys or species management, then there are associated benefits in reduced activity costs and greater ability to meet the other objectives of the NWFP. Criteria include:

- There are many known sites in matrix land allocations.
- There is a large increase in number of known sites since initiation of surveys.
- The species requires preproject surveys, but little is known about suitable habitat. Therefore it is difficult to target surveys to likely habitat, so surveys are required for every project.
- The species is in category B, and there are deadlines for completing strategic surveys.
- Geographic areas with the greatest project activity and therefore the greatest risk to loss of sites and conversely the greatest impact to meeting other objectives of the NWFP.
- Species is in category C or D, and the agencies are ready to identify high-priority sites.
- The species has a high cost and or impact to management (preproject surveys, withdrawal of operable land in the matrix).
- The species likely will change category when new information is obtained.

Operational and logistical factors—Given the number of species and size of the NWFP area, it is not possible to survey for all species information simultaneously in a single year or across all provinces. Logistical considerations may be evaluated in order to increase survey efficiencies. These include:

- Field surveys and data collection can be done efficiently and effectively (reliable protocols exist and are available, expertise is available).
- Geographic/habitat proximity or similarity.
- Potential for multiple-species surveys.
- Determining or anticipating time sequence for information needs and surveys, which includes timing for out-year surveys (e.g., is there a sequence for gathering information where future surveys require or build on data collected in previous years).
- Out-year planning for completing strategic survey requirements as defined in the ROD (USDA and USDI 2001).
- Resource or budget constraints.
- Testing or developing survey protocols or methods.

Evaluation of Approaches and Options

Strategic surveys may be accomplished by using various approaches and methods (such as acquiring information from field surveys, research studies, herbaria, museums, literature, field units, and other sources, and by using various analytical tools such as habitat models). Each approach contributes information toward improving our

ability to manage for species persistence. These approaches are explored, developed, and analyzed for effectiveness and efficiency for acquiring the needed information for all species. No one approach can generate all the information needed for all species or in all provinces of the NWFP area. Therefore, various combinations of approaches need to be examined and analyzed for costs, resources required, timeliness of completion, amount and efficiency of information gained, and associated uncertainties. Where possible, approaches should build on or complement previous study or research designs.

Strategic Survey Implementation Guide

The ROD (USDA and USDI 2001) requires the development of an SSIG to document final decisions on the conduct of strategic surveys. The guide will contain such information as the strategic survey needs for all species or species groups at the range-wide or regional scale, the benefits of addressing information needs, the methods and scale that would best address information needs, and the relative priorities or priority-setting criteria.

The SSIG is a dynamic document, particularly during the first years of implementation while information needs are clarified. The SSIG will be updated annually to reflect changes in information and priorities as a result of previous years' accomplishments or new information. Additionally, changes in species category placement or other new information may lead to new questions and information needs. The SSIG, with annual updates, will help ensure deadlines listed in the ROD standards and guidelines (USDA and USDI 2001) are met and identify the magnitude and likely duration of the strategic survey program for planning and scheduling purposes.

Development of the strategic survey implementation guide—The SSIG focuses annual work planning on the priority information needs, provides information for long-range planning, and facilitates the grouping of surveys for efficiency. The regional survey and manage team will be responsible for developing and updating this document.

The implementation guide will include, by species or taxa group:

- A summary of the information needs proposed to be answered by strategic surveys.
- The benefits expected by answering each identified need, either in terms of increased assurance of species persistence or reduced costs or impacts.
- Identification of methods (and scale) that would best meet the information needs.
- Relative priorities or priority-setting criteria.

The SSIG addresses information needs requiring research or analytical approaches to gather and analyze specific data to address specific questions. The SSIG identifies the annual strategic survey program of work and allocates resources to meet specified objectives. The recommended program of work integrates the prioritization of species and information needs performed previously with the cost/benefit/efficiency analysis of the various approaches. An effective program considers the contributions of various approaches (see section on "Information-Gathering Approaches"). Species or surveys may be grouped for cost efficiency. Preliminary identification of available resources, including the administrative levels that will participate, is conducted at this stage. The SSIG is subject to review by the Regional Interagency Executive Committee to ensure identified information needs and priorities will further the objectives of the NWFP (USDA and USDI 2001).

Annual Work Plan

Development—An annual work plan for strategic surveys and research will be developed based on the SSIG. The annual work plan combines the priorities and approaches identified in the SSIG with the management guidance and budget constraints. The annual work plan will have to include tasks that involve field efforts, laboratory work, and information management and analyses that require multiple survey seasons and years to complete. All aspects of the annual work plan should be included in the document.

Implementation—Implementation of the annual work plan for strategic surveys includes all aspects of the planning and conduct of surveys, research, or other information-gathering activities. This may include hiring of personnel, mobilizing crews, contracting, selecting survey sites, scheduling site visits, developing protocols, etc. As surveys are completed, data are entered into the Interagency Species Management System (ISMS) database. Results from surveys and research are made available and housed within the information management component of the survey and manage program. Responsibility for implementing the annual survey and manage work plan and followup actions will be delegated to administrative units or groups of administrative units as part of their funded program of work.

Institution and implementation of a quality assurance-quality control program are essential to the success of strategic surveys. Obtaining consistent information of known quality will greatly facilitate the adaptive-management processes for the NWFP survey and manage program. Important aspects to include are survey and site protocols; survey crew training; specimen collection and processing; taxonomic identification; data recording, entry, storage, retrieval, and documentation; and the information analysis and reporting processes.

An overview of a model for all the survey and manage component processes is shown in figure 2. It is within these processes that strategic survey information is intended to be applied and modified as needed.

Analysis and reporting—Data and information generated by strategic surveys and research are used to prepare reports and synthesize information for consideration during the annual species review process and the species information-needs analysis. Strategic survey information also will be summarized and available for incorporating into management recommendations and predisturbance survey protocols. It becomes part of the existing information used in annual identification of information needs and priorities. Information from completed surveys, and the identification of new survey needs, will be incorporated into the SSIG as appropriate. Strategic survey accomplishments will be summarized in the survey and manage annual report.

Strategic survey data and results are analyzed and interpreted consistent with design parameters of the survey, and when appropriate, clearly document measures of uncertainty and inferences to populations or areas. Clear summarization and presentation of such data will be required to ensure their proper incorporation into the annual species review process.

Results from strategic surveys will be evaluated to determine their effectiveness in meeting the objectives and addressing the information needs stated in the SSIG and annual work plan. It is anticipated that the conduct of strategic surveys will evolve over time as methods for different approaches are evaluated for their efficiencies and for their ability to address specific information needs.

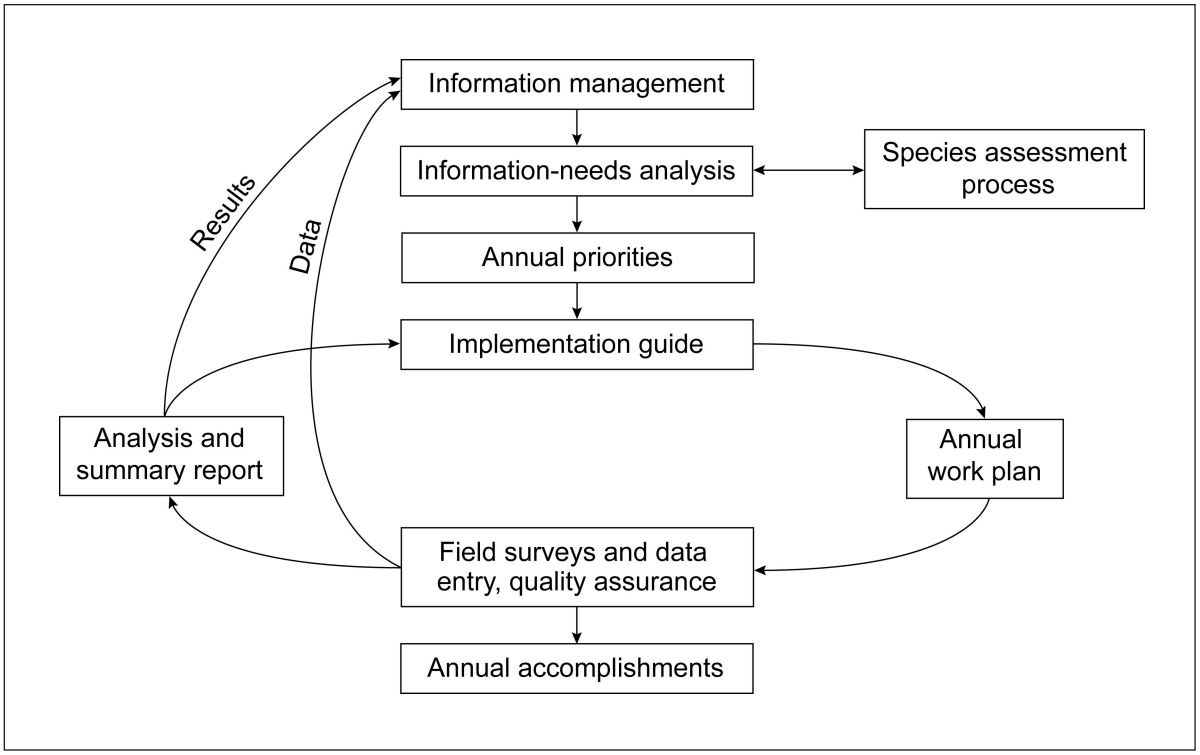

Figure 2—Strategic survey implementation model overview.

Accurate analysis and reporting will depend on thorough documentation at all stages of the information gathering and analysis processes. Strategic surveys for rare and uncommon survey and manage species are a complex undertaking and may take several years to complete for some species. The framework strongly emphasizes documentation because of the interagency nature of the program, number of species, geographical area, application of new approaches, and lack of information on the species and their habitats. Information gathered in the early years of the program will be substantially more useful for analysis purposes in 10 years if accompanied by thorough documentation.

Information Management

This component includes all aspects of managing survey and manage species information and documents the current state of knowledge for these species. The strategic survey program for the NWFP will produce considerable information, covering numerous species over a large region, that is contributed by a substantial number of individuals and organizational units. Information management includes data entry, data quality assurance and quality control, database management, data retrieval, data storage and archives, current management recommendations and survey protocols, species distribution maps, results and documentation of the annual species review process, species information needs analysis, and documentation of the design, analysis, and results of strategic surveys.

The ISMS database is the central repository for data input and retrieval. Information from strategic surveys (and other sources) is maintained primarily in the ISMS database and associated geographic information system (GIS) files. Information in formats

not appropriately stored in ISMS is maintained in files kept by staff in the regional survey and manage program. The species-review process and species information-needs analysis shown in this framework are based primarily on, but not limited to, the information stored in the ISMS database.

Annual Species-Review Process

The annual species review is described in the ROD (USDA and USDI 2001) and uses information from strategic surveys and associated analyses. The review follows three steps: (1) application of a systematic filter to determine the level of new information that is available for each taxon, (2) review of all information by species, and (3) development of recommendation(s) for appropriate management actions for each species. The results of this process may lead to recommendations for changing species assignments to survey and manage categories, or to changes in the management recommendations and survey protocols, or to changes in information needed about a species. Results that identify additional information needs flow into the species information-needs analysis, and provide further guidance for the development of strategic surveys.

Adaptive-Management Process

The standards and guidelines in the ROD (USDA and USDI 2001) detail the adaptive-management process for the survey and manage component of the NWFP. This process covers the acquisition and evaluation of new information relative to survey and manage species in order to implement changes or refinements to survey and manage standards and guidelines. Application of new information results in one of three management outcomes:

- Maintain status
- Change in the status or category of a survey and manage species
- Removal of a species from survey and manage list

New information is used to develop or revise management recommendations, survey protocols, and the SSIG. Species also can be evaluated for addition to the survey and manage list if they meet the criteria outlined in the ROD (USDA and USDI 2001).

Some management actions, such as changing a species from one category to another, may trigger the need for collecting different information to address the persistence and management questions associated with the new category. The new information needs are integrated into the species information-needs analysis to be addressed in subsequent strategic surveys.

The ROD (USDA and USDI 2001) established a process and criteria for assessing the need for continued strategic survey efforts. Strategic surveys for a species are considered to be complete when any one of the identified criteria is met, and the resultant information has been compiled and analyzed, and presented in the appropriate form for use by the target audience. The criteria for discontinuation of strategic surveys are listed in the ROD (USDA and USDI 2001: 30).

Primary Questions and Information Needs Addressed by Strategic Surveys

The original NWFP ROD (USDI and USDA 1994) identified the overarching question for rare and uncommon species: Does the NWFP provide a reasonable assurance of species persistence? Based on a negative answer to this question, the ROD (USDA and USDI 2001) outlined three criteria for a species to be included in survey and manage standards and guidelines:

1. The species must occur within or near the NWFP area and have potentially suitable habitat within the NWFP area.
2. The species must be closely associated with late-successional or old-growth forest.
3. The reserve system and other standards and guidelines of the NWFP do not appear to provide for a reasonable assurance of species persistence.

The ROD (USDA and USDI 2001) next listed three primary questions (shown below) that focus strategic survey efforts. Each question is described in general terms and then expanded into detailed subsets of questions that generate specific information needs. These questions drive the species information-needs analysis. Not all questions are relevant for each species and so will not necessarily be targeted in strategic surveys. Some subquestions are repeated under the different primary questions because of similarity of information needs. Reference to sites includes data derived from both known sites and estimated numbers or predicted locations of sites based on probabilistic sampling designs and habitat models.

1. Does the species need the survey and manage mitigation to assure persistence?

This question addresses whether the NWFP system of reserve land allocations provides for species persistence, a basic criterion for a species to be included in the survey and manage standards and guidelines. To evaluate this criterion, specific questions focus on rarity and distribution within land allocations and assess the degree to which the reserves provide for species persistence.

Late-seral/old-growth forest association is another required criterion for a species' inclusion under the survey and manage standards and guidelines. Knowledge of old-growth forest association is commonly lacking for many species in categories E and F and remains uncertain for some species in other categories.

Specific questions	Information needs
Is the species known to exist in the area of the NWFP?	• Historical known sites in plan area • Close historical known sites outside plan area • Definition of potential suitable habitat • Distribution of suitable habitat in NWFP area • Occupation of suitable habitat in the NWFP area
Does the species meet the criteria for close association with LSOG forests?	• Characterization of species habitat • Identification of high-probability habitat • Relative abundance and frequency in LSOG forests compared to younger forests
Do the reserve land allocations provide for species persistence?	• Geographic distribution of sites relative to land allocations • Number and distribution of sites in reserve land allocations • Number and distribution of sites in reserve land allocations necessary to provide for persistence

	• Population status of sites in reserve allocations • Quality of sites in reserve allocations (habitat and population) • Description of suitable habitat • Amount and distribution of suitable habitat in NWFP area relative to land use allocation • Identification of amount of suitable habitat and distribution needed in reserve allocations • Portion of suitable habitat that is occupied • Connectivity of occupied sites needed for stable or persistent populations
Do other standards and guidelines of the NWFP provide for species persistence? (e.g., coarse woody debris, green-tree retention, snag retention)	• Determine the habitat requirements of the species • Determine which standards and guidelines provide habitat components required by the species • Determine if these standards and guidelines provide what is necessary to assure species persistence

2. What are the primary concerns for species persistence?

If a species meets the criteria for management under the survey and manage standards and guidelines, then an evaluation of the species' status is conducted to determine the primary concerns for persistence. Examples of information needed to address this question include species rarity, distribution, distribution of known sites, and population status, as well as knowledge of specific habitat requirements and potential suitable habitat in the NWFP area. In addition, descriptions of status and trends in species and habitat, knowledge of specific threats to persistence, and assessments of risk to persistence can contribute information for development or revision of management recommendations.

Specific questions	Information needs
Is the species rare or uncommon?	• Number of known sites • Number of potential sites
Are the known sites still extant?	• Time since last observed • Presence at known sites
What is the population status of the species?	• Historical number of known sites • Number of extant sites • Estimated number of occupied sites • Relative abundance at inhabited sites • Size, area, density, and extent of inhabited sites on landscape • Population trends

Do reproduction and life history characteristics create additional risk to maintaining existing or future populations?	• Life history information characteristics that might create additional risk
What is the distribution of the species?	• Range of species • Distribution relative to natural range • Portion of suitable habitat that is occupied
What is the distribution relative to the land allocations?	• Number of sites inside and outside reserves
How do the reserve land allocations provide for species persistence?	• Geographic distribution of sites relative to land allocations • Number and distribution of sites in reserve land allocations • Number and distribution of sites in reserve land allocations necessary to provide for persistence • Population status of sites in reserve allocations • Quality of sites in reserve allocations (habitat and population) • Description of suitable habitat • Amount and distribution of suitable habitat in NWFP area relative to land use allocation • Identification of amount of suitable habitat and distribution needed in reserve allocations • Portion of suitable habitat that is occupied • Connectivity of occupied areas needed for stable or persistent populations
Is dispersal capability limited relative to federal habitat, potentially isolating populations?	• Dispersal capacity and requirements • Fragmentation of suitable habitat • Status of isolated populations • Historical and projected connectivity
What are the habitat requirements? How specialized are they? Are the microsites limited? What is the distribution of suitable habitat? What is the occupancy of suitable habitat?	• Description of suitable and high-probability habitat • Description of microsite habitat • Ecological amplitude • Geographic distribution of suitable habitat • Portion of suitable habitat that is occupied

Is the habitat trend declining? What is the relationship of population dynamics to habitat dynamics? What are the spatial and temporal distribution and availability of suitable habitat?	• Amount and distribution of suitable habitat (both in time and space) • Fragmentation of suitable habitat • Portion of suitable habitat that is occupied • Successional trends of potential and suitable habitat • Disturbance regimes (both natural and management)

3. How do we manage species and habitats to assure species persistence?

Management recommendations provide both short- and long-term guidance for species and habitat management. These documents summarize current knowledge on species natural history, ecology, distribution of known sites, and habitat requirements and response to management treatments. They also may identify high-priority sites for uncommon species or provide other information to support management direction. Where detailed knowledge on some or many of these aspects is missing, management recommendations may be based on expert opinion. To build knowledge and make scientifically based management decisions, specific subquestions target the gathering of information directly relevant to enhancing our ability to manage species and habitat.

For categories C and D species, not all known sites may be needed, and a subset of "high-priority" sites may be selected and managed to assure species persistence. For these species, questions and information needs focus more on population size, habitat associations, landscape and regional distribution of known sites or potential suitable habitat, estimated occurrences in land allocations, quality of known sites, and how sites in reserve land allocations contribute to species persistence. Information gathered to address these questions provides the underpinning for proper habitat management at the site level to maintain species presence, and at the regional scale to maintain well-distributed populations.

Specific questions	Information needs
What are the habitat requirements? How specialized are they? Are the microsites limited?	• Description of suitable and high-probability habitat • Description of microsite habitat • Ecological amplitude
How do we manage habitat at the site scale? What are the natural disturbance and management action risks to maintaining habitat and species persistence?	• Habitat information to develop or revise management recommendations • Disturbance history of known sites • Response of species to disturbance
How do we select high-priority sites for management to assure persistence?	• Habitat quality of known sites • Number of individuals at known sites • Size of the occupied area • Geographic distribution (connectivity) of occupied areas • Threats to occupied area

What is the distribution of the species relative to the land use allocations? How do sites in the reserve land allocations contribute to or provide for persistence (function as high-priority sites)?	• Geographic distribution of sites • Extent of the range of species within the area of the NWFP • Distribution of suitable habitat • Distribution of suitable habitat relative to land use allocation • Occupancy of suitable habitat
What is the population status of the species relative to the land use allocations?	• Historical number of known sites • Number of extant sites • Relative abundance at inhabited sites • Size, area, density, and extent of inhabited sites on landscape, known and estimated • Occupied areas relative to land use allocation • Population trends

Information-Gathering Approaches

The NWFP strategic survey framework assumes that several methods and approaches will be used to obtain the survey and manage information identified through the species information-needs analysis. Selection of the appropriate method(s) will depend on the information needs and objectives for the target species, along with associated budgets, timelines, and logistical considerations. The basic objectives of strategic surveys are to build an information base for survey and manage species, identify sites where species occur, document sites and habitats of survey and manage species, and conduct surveys designed to answer specific questions. Relevant information can be provided by design-based samples (statistical approaches), use of modeling techniques, research and experimental designs, field observations, and acquiring available information from literature, museums, herbaria, and species experts. It is anticipated that combinations of these approaches will be used to address the range of survey and manage questions and information needs. To facilitate development and selection of specific approaches to meet the combinations of species information needs, this section presents various approaches and general guidance on their implementation.

Strategic surveys may be conducted at different scales and use various approaches, depending on objectives and identified information needs (USDA and USDI 2001). These may be categorized as (1) broad-scale surveys to detect range and habitat associations along with estimates of rarity; (2) mid- to fine-scale surveys that refine estimates of abundance, habitat associations, and provide information for management of species and their habitat; and (3) research and surveys to provide information on specific species population or habitat concerns. The questions, subquestions, and their relation to the primary NWFP survey and manage questions presented previously also provide guidance to address these categories of information needs.

Broad-scale surveys provide information on species ranges and distributions, habitat associations, and rarity to address survey and manage questions for a species range or regional scale. Surveys addressing questions about species habitat associations, ecological distribution, association with LSOG forests, occurrence in NWFP land allocations, and spatial distributions (e.g., species geographic range, environmental gradients, etc.) will provide information for the annual species review, contribute information to assist in species management, and direct future surveys. Additional information,

such as estimates of the frequency of occurrence, can aid in the assessment of the degree of rarity, and help address management questions such as identifying high-priority sites. Survey approaches at the broad scale may include statistical sample designs, spatial habitat modeling, and research studies. Key features of broad-scale surveys are the ability to address multiple objectives and to include multiple species.

Surveys at mid to fine scales typically focus on gathering information to refine understanding of the distribution, likelihood of occurrence, and habitat associations of individual species, or for a few species within a taxonomic group. Surveys at this scale also can provide information that can assist in the management of species and their habitats and may be used to more effectively target future survey areas. Typical objectives of these surveys are to increase the number of sites where a species is known to occur and to gather more detailed data and observations at occupied sites. Occupied sites detected during predisturbance surveys also contribute to the number of known sites.

Survey approaches at the mid to fine scale include (1) known site surveys; (2) purposive surveys and expert searches; (3) probability sampling methods, including random grid, simple random, stratified random, and cluster samples, with or without an adaptive component; (4) model-assisted probability and nonrandom survey designs; (5) research studies; and (6) acquiring available information from literature, museums, herbaria, and species experts.

Probability-Sampling Approaches

Probability-based surveys provide quantitative information on the number of occurrences of species across the NWFP area, the distribution of the species, and associations of the species with LSOG forest. Random selection of the sample plots is a critical element of such surveys. Random selection guards against bias in the site selection (Lohr 1999, Rice 1995). It is the basis for calculating measures of uncertainty, including standard errors and confidence intervals (Rice 1995), for estimates of population characteristics such as proportions and numbers of occupied sites. Random selection is also the formal basis for statistical tests of hypotheses of, for example, LSOG associations of the individual species. Without random selection of sites, it is not possible to compute measures of uncertainty or to carry out formal statistical hypotheses tests.

Another important requirement for all the probability-based sample surveys is that the sampling protocol remain the same at different locations, with different surveyors, over time. This ensures that data from different areas, perhaps collected by different crews in different years, are comparable. In general, these survey approaches must be flexible enough for regionwide implementation, be standardized and repeatable, and permit the calculation of quantitative estimates of desired population parameters.

Survey designs are developed to meet specific objectives based on questions and information needs, and to provide information on survey and manage species in a timely manner. A single design is not applicable for all survey and manage species information needs, nor even for all parts of a single species' range. Sample designs should have sufficient flexibility so they can be modified as information is acquired. Specific statistical guidance will be required in the development of statistical survey designs, to address compatibility with ongoing or completed strategic surveys, and to aid in analysis of data and interpretation of results. Statistical review and consultation also will help ensure that information collected at the plot level fits into the overall, regionwide sample designs. An ad hoc statistical advisory committee has been established to fulfill these advisory needs.

Several different types of probability sampling methods are briefly described below, and their advantages and disadvantages are discussed.

Stratified random sampling on a grid—The objectives of this type of survey are to include multiple species at the regional scale and to provide probabilistic estimates of species abundance and distributions relative to land allocations and LSOG versus non-LSOG forests (see Cutler et al. 2001). As the name suggests, stratified random sampling on a grid involves taking a stratified random sample of sites from a grid that is overlaid on the landscape at a regional scale. Such a design can accommodate multiple-survey objectives and be used to sample for several species, or groups of species, simultaneously at a regional scale. These designs may be used to provide population estimates and inferences about species abundances, distributions, and associations within the entire population, within the individual stratum, and within subpopulations that may lie within or be crossed with the sampled strata. This basic design can be applied—by intensification of the underlying grid structure—to construct surveys at the watershed, land allocation, administrative unit, or province scales. Also through intensification of the grid density and by restricting areas of interest, this type of design may be used to address survey objectives at smaller scales, while maintaining compatibility with the regional data.

For initial implementations of this class of designs, stratification has been kept to a minimum. Specifically, just four strata have been used: LSOG within the reserves, non-LSOG within the reserves, LSOG in the matrix, and non-LSOG in the matrix. There are two main reasons for restricting the amount of stratification at this time. First, little is known about many of the species so there is little one could use for stratification purposes. Second, for reasons of efficiency, the initial surveys have been conducted for many species at the same time. Criteria that might be useful for stratifying sample surveys for one species, or group of species, may be irrelevant for stratifying for other species. This is the issue of surveys meeting multiple objectives. Note that restricting the initial stratification in no way restricts any poststratification or estimation for subpopulations of interest.

Three examples of a random-grid approach have been implemented for strategic surveys in the NWFP area. In northern California, the GOBIG2K program to survey for selected survey and manage species adopted a stratified random sample on a grid approach with eight strata: riparian reserve and nonriparian reserve classifications within the four national forests in which the surveys were conducted. A random sample of Forest Inventory and Analysis (FIA) sites was selected within each stratum, with the numbers of sites selected being roughly proportional to the areas within the strata.

The second example of a stratified random sample on a grid is the fiscal year 2000 strategic survey pilot design (Cutler and Edwards 2002) using the current vegetation survey (CVS) grid in three study areas (Gifford Pinchot, Umpqua, and Siuslaw National Forests, plus adjacent Bureau of Land Management lands). The study areas were then divided into two stand-age strata (non-LSOG and LSOG, as determined from the CVS plot data) and two land allocation strata (reserve and matrix land allocations). Within each of these four strata, a random sample of sites was selected.

The third example of a stratified random sample on a grid that has already been implemented is the fiscal year 2001 strategic survey random-grid design, which uses a spatially balanced stratified random sample (Stevens and Olsen, in press a, in press b) of CVS and FIA sites, across the entire NWFP area by using the same four strata as the fiscal year 2000 pilot program.

Information acquired through the stratified random grid design can be used in the annual species review process. By using the stratification scheme outlined above, questions can be addressed regarding species association with LSOG forests and species distribution relative to land allocations. Also, population estimates can provide information to be used in determining the degree of rarity of species.

Potential benefits:

- Can be cost effective when information is desired on a large number of species about which little is known.
- Provides quantitative estimates of the frequency, number, and proportions of occupied sites for each species, with confidence limits, by strata and subpopulations of interest.
- Can be applied in situations where some or all of the following are true: (1) scant prior knowledge about species range, distribution, and habitat associations; (2) multiple objectives at large scales; and (3) multiple species with similar information needs.
- Can conduct surveys for multiple species at all sites.
- Provides for unbiased estimates of population parameters such as totals and proportions, and supports hypothesis testing of frequency of occurrence in habitats (LSOG versus non-LSOG) and land allocations.
- Builds on existing regional surveys and data (CVS and FIA).
- Allows for sampling to be carried out more intensely in strata that are of particular interest (e.g., LSOG within the reserve) or in locations where species are thought to be more likely found.

Considerations and limitations:

- Access and sampling at remote sample locations are difficult and expensive.
- Can be logistically complex, as it requires consistent sampling across large areas and multiple agency boundaries.
- Likely to provide more information for the “uncommon” versus “rare” survey and manage species.
- Unlikely to find species that are extremely rare or have low detection rates.
- With low detection rates come few detections, and hence the data are insufficient to provide inferences such as LSOG association and distribution relative to land allocations.
- Current vegetation survey and FIA plots are large and generally do not encompass a homogeneous community, but more typically include a variety of sites and habitats; it is difficult to conduct analyses or draw conclusions regarding habitat associations except in a general sense.
- Application of stratification scheme requires that the strata information be available prior to sampling for all grid points. For the surveys based on CVS sites, this has been true, but for surveys off the CVS grid, information such as stand age may not be available.

We anticipate that as additional information about species range and habitat associations develops, for individual species or small groups of species it will be possible to stratify on more variables and thereby substantially increase the efficiency and effectiveness of these stratified random surveys for that species or group of species. We also anticipate that model-based approaches will provide information, along with field observations and research results, to refine population and strata definitions, supporting greater targeting and efficiency of these design-based approaches.

Stratified random sampling—A stratified random sampling approach involves dividing the landscape into strata, typically based on ecological variables like stand age, and then randomly selecting plots of a fixed size within each stratum (see Cochran 1977, Lohr 1999). This sampling method differs from stratified random sampling on a grid in that the sample plots do not have to be selected from a grid such as the CVS and FIA grids. One application of stratified random sampling is when the area to be surveyed is small and grids like the CVS and FIA grids are too coarse to yield enough sample points. Objectives of this approach are to determine frequency of species occurrence based on habitat, and to assess range, distribution, and abundance of survey and manage species relative to habitat parameters.

Spatial habitat models can be used as a basis for stratification. Some species habitat models produce maps of different strata defined by likelihood of suitable habitat (e.g., high, moderate, low, and not likely). Random samples are then allocated to the different strata, and plots are installed to determine species presence and habitat parameters. One objective of this kind of sampling is to validate the habitat model by providing frequency estimates for target species in the different habitat strata, but data from such samples also may be used to estimate population parameters such as occupancy rates. Because survey and manage species are assumed to be rare on the landscape, this approach would use an ecological stratification to identify likely areas or habitat conditions for each target species. And, because the survey effort is based on likelihood of species habitat, it would potentially generate more data on species distribution and habitat requirements than the stratified random-grid approach, particularly for rare species. On completion of the validation sample, a population estimate is made, and the habitat relations and range of the target species should be well known for the geographic area of the habitat model. Resulting information could be used to address questions about the amount and distribution of likely habitat relative to land allocations, frequency of occurrence in different habitat strata, and identification of high-priority sites, and to provide habitat and species information to assist in species management and the annual species review. The model also can be used to find new sites of survey and manage species.

Other types of strata could be defined and sampled for the occurrence of survey and manage species. An example is an ecological stratification based on plant associations and stand age. A map depicting groups of plant associations and classes of stand age is generated, and a random sample is selected from the different habitat strata. Consideration of the number of strata is important to ensure that the defined strata are meaningful, and to determine the number of sample points needed to provide estimates and draw inferences. Increasing the number of strata will require a larger number of sample points and increase associated costs. In this example, it is not necessary to have prior knowledge of a species' habitat requirements. Multiple species could be surveyed for at each sample point. This type of sample design would provide information on distribution and abundance of survey and manage species in

the different habitat strata and could be used to address questions about habitat associations, LSOG association, and distribution of habitats relative to NWFP land allocations.

Potential benefits:

- Provides quantitative estimates of the frequency of occurrence in different mapped habitat strata.
- Provides habitat-based information on species distribution.
- Can incorporate multiple species by aggregating or integrating single-species habitat models, or survey for multiple species in the ecological stratification that is not species-habitat based.
- Contributes to analysis of distribution of suitable habitat relative to land allocations.
- May be an efficient design for rare species because stratification is based on species habitat.
- Builds on existing regional data (potential natural vegetation mapping and regional ecology database).

Considerations and limitations:

- Application of stratification scheme requires that the strata information be available prior to sampling for all grid points.
- Access and sampling at remote sample locations can be difficult and expensive.
- If detection rates are very low, data may be insufficient to provide population estimates and inferences. However, detection rates are expected to be higher than the stratified random-grid approach.
- Stratification based on ecological criteria works best for a single species or small number of species. When information is desired for a large number of species in a single survey, only coarse stratifications can be used. When a large number of species are being sampled for, conducting a large number of separate, highly stratified random surveys for individual species or groups of species may not be cost-effective.

Systematic sampling—Contrary to its name, systematic sampling is a form of probability (random) sampling (see Shiver and Borders 1996). A grid is imposed on the landscape with a random “starting” point. The grid could be an existing regional sample grid, such as CVS or FIA grid, or it could be a new grid customized to the problem at hand. For example, one option is to establish a grid with a random starting point at a smaller scale, such as a province, administrative unit, watershed, or NWFP land allocation unit such as a late-successional reserve or matrix area. These surveys differ from stratified random samples on a grid in that no stratification takes place and all sites on the grid are sampled, not just some randomly selected subset. One portion of the lichen air quality surveys was of this form. Data from the lichen air quality surveys have been used to provide the survey and manage program with information about abundances and LSOG associations of survey and manage lichen species within the NWFP area (Edwards et al. 2001).

The survey may include a large number of sample sites where survey and manage species do not occur or were not observed. Estimates of overall population sizes could be made by using data collected from systematic samples, and some statements about range and extent of the species could be made as well, although confidence in these estimates will depend on sample size and frequency of occurrence. This kind of sampling is cost effective when information on many species is desired simultaneously, but rare and hard-to-detect species will typically not be detected in such surveys.

Potential benefits:

- Cost effective for searching for many species simultaneously.
- Provides quantitative estimates of the frequency and number of occupied sites, with standard errors and confidence limits.
- Supports statistical hypothesis tests of, e.g., late-seral association.
- Can be applied in situations where some or all of the following are true: (1) scant prior knowledge about species range, distribution, and habitat associations; (2) multiple objectives at large scales; and (3) multiple species with similar information needs.
- Surveys for multiple species at all sites.
- Likely to provide more information for the “uncommon” versus “rare” survey and manage species.

Considerations and limitations:

- Access and sampling at remote sample locations can be difficult and expensive.
- If detection rates are low, data may be insufficient to provide population estimates and inferences.
- May be inefficient or unsuccessful design for rare species or those with low detection rates; rare species, species associated with rare habitats, or species with low detection rates are unlikely to be observed in more than a small number of sites, without substantial sampling effort.

Adaptive cluster sampling—In addition to random designs, there are other statistical approaches such as adaptive cluster sampling that offer potential for providing information (see Thompson and Seber 1996). The objective of this type of sampling is to estimate the frequency of distribution of the target species within the sample area. A sequential sampling method is used as a way to sample rare events. This approach assumes that the rare events are aggregated in some way. For example, sites that are near occupied sites may be more likely to be occupied than distant sites. This approach starts with the determination of an occupied site, either as a previously known site or established by the sampling crew. Subsequent sampling effort is allocated to clusters of sites that neighbor the initial sample sites in which the species was found. Obviously, the adaptive nature of the sampling method must be taken into account in the estimation scheme; simple averages from the sampled clusters will clearly overestimate the incidence of the rare event. Additional information on cluster sampling approaches is presented in Cutler et al. (2001).

There are logistical issues to consider with adaptive cluster sampling methods (Cutler et al. 2001). One issue is the fact that a sampling crew may not know whether they will be sampling points adjacent to the current sample point until the data from the current sample point are available. A second potential issue is that the approach requires that the field crew correctly identify the target species in the field or make repeated visits following laboratory efforts to identify the species. Another aspect inherent to this type of sampling is that information is concentrated in localized geographic areas and cluster samples may be more like replicates than new data points. Distance between adaptive cluster sites may be different for different species, and it may be difficult to determine what is a "new site or population" as information is limited on this aspect of population biology for survey and manage species. Field trials are needed to determine if this is a feasible approach for strategic surveys.

Potential benefits:

- May result in efficient allocation of survey efforts resulting in greater detections of rare species.
- Uses prior knowledge of known sites.
- Estimates frequency of distribution within each cluster sample area.
- If the initial sites are randomly selected in some way, then the data from these samples may be used for inferential purposes, such as estimating population numbers of occupied sites and associations with LSOG.

Considerations and limitations:

- Requires field identification of targeted species.
- May further habitat biases associated with known sites.
- Establishing locations of adjacent survey clusters may be logistically challenging and inefficient.
- Requires definition of boundaries of a single site; i.e., whether two adjacent sites represent one or two occupied sites for population estimation and annual species review processes.
- Assumes that nearby sites are more likely to be occupied than distant sites.
- Concentrates information within localized geographic area rather than more extensive geographic coverage.
- Will fail to locate new sites outside of the "cluster" sample.

Considerations in design selection—Several factors affect the ability of any selected design to meet the stated objectives of survey and manage standards and guidelines. These include different information needs, issues of detection, and logistics.

Different information needs lead to different sampling designs, and no one design can meet all information needs. Clear objectives based on questions must be articulated and adhered to throughout the strategic survey design, implementation, and analysis processes. Changing or adding additional objectives during implementation may impact the ability of the sampling design to provide defensible estimates of the desired parameters.

Detection can constrain design selection and implementation. Because occurrences of survey and manage species are essentially rare events in time and space, detection rates for many species can be as low as 1 in 100, or 1 in 1,000 visits or even less. We currently have poor estimates of detection rates for most survey and manage species.

Two aspects of detection should be considered. First, when a species occupies few sites, achieving the desired number of detections may require surveying a large number of sites (i.e., a large sample size). The second issue is one of detecting the species when it occupies the site. Species that are not readily visible during the visit to the site, only appear infrequently, or otherwise exhibit characteristics that make detection by the survey crew difficult, also will have a low detection rate. Lack of information on detection affects our ability to provide accurate estimates for survey and manage species. In general, low detection rates will result in underestimates of the actual number of occupied sites. This is partially due to the fact that many rare organisms will have detection rates of zero unless the sample size is large. We anticipate that as strategic surveys progress, sufficient information will accrue to allow the estimation of detection rates and modify the sampling design and estimation process.

Logistical constraints affect the ability of survey and manage field crews to visit the required sample sites. For example, in some cases, randomly selected sample sites will have to be removed from the list for reasons such as inaccessibility. This is a minor constraint that has no major impact on the overall design. However, the documentation of the field implementation must include the number and rationale for sites removed from the design to facilitate the correct estimation of population parameters.

Model-Based Approaches

This approach uses modeling techniques to address the questions and information needs identified for survey and manage species. Models can help define the questions, organize thoughts, make data understandable, communicate and test understanding, and make predictions (Starfield and Bleloch 1991).

Various types of modeling approaches may be used depending on the defined objectives and questions to be addressed for survey and manage species. Use of different approaches depends on the amount and type of data available, and what the level of understanding is relevant to the questions being asked. Models can be statistical, empirical, expert-based, spatial or abstract, explanatory, predictive. Models can be developed and tested at different spatial scales. Modeling approaches generally will be of two types: (1) model-based techniques that link data and hypotheses about species relations and broad-scale habitat and environmental relations to formulate forecasts of range and distribution and (2) empirical-based models that use statistical analyses techniques.

Current efforts to develop model-based forecasts include the potential natural vegetation model approach developed by J.A. Henderson and the USDA Forest Service Pacific Northwest Region Ecology Program (Henderson 2001). This GIS-based spatial approach builds on existing methodology and provides maps of species habitat categorized by likelihood of suitable habitat (high, moderate, low, and no). The potential natural vegetation species habitat model can be used as the basis of stratification for sampling to determine frequency of species occurrence in classes of habitat, as well as a tool for guiding purposive surveys to find new sites for target species. In general, the approach will be more applicable for those species with at least 20 known sites, but also has been used effectively for species with as little as 3 known sites. Habitat

model validation will use statistically designed surveys within the different mapped habitat strata. A validated habitat model may serve as the basis for forecasting the probabilities of occurrence in unsampled portions of the landscape, forecasting the amount and distribution of suitable habitat, as well as the probability of occupancy within habitat strata.

Statistical models represent another approach to providing information about species distribution and habitat associations. Regression and discrimination analyses potentially will provide information on the strength of the relations and forecasts of the likelihood of occupied habitats as a function of mappable characteristics (Hastie et al. 2001). Hoeting et al. (2000) discuss the development of maps of probabilities of occurrences of rare species and use a Bayesian approach with a modification of the autologistic model to incorporate covariates. They explicitly state that such maps may be used for policy decisions or to develop future sampling plans. Edwards et al. (2001) use generalized linear models (McCallagh and Nelder 1989) to predict probabilities of occurrence of survey and manage lichen species, and in subsequent work have applied generalized additive models and classification trees (Hastie et al. 2001) for the same purpose. One potential application of such models would be to provide a means of extrapolating probabilities of occupancy into unsampled areas. However, successful application will depend on correctly identifying the relevant habitat characteristics and relations, potentially at both the large and microsite scales, and coping with the rarity of occurrence and detection issues. Application to the rarest species, (those with fewer than 20 known sites), will be problematic owing to the sample size degrees of freedom and the limited amount and uncertainty of information used in the development of a model.

The mid- to fine-scale model-based approaches are generally based on a restricted area of interest, or range of habitat conditions. This permits a more focused approach in areas where the species is known, or likely to occur, thereby increasing the likelihood of success. Often the desired information at this scale is associated with model development and application as well as specific management purposes. Model-based estimation at this scale may be both predictive and explanatory.

Explanatory models may serve to improve understanding of the ecological relations underlying survey and manage species distributions and habitat associations. A spatially explicit habitat model can be used as a tool to guide purposive surveys with the objective to find new sites of target survey and manage species. These approaches also can provide information to aid in identifying high-priority sites, selecting high-priority sites for management, and recommending management actions at those sites.

Explanatory or expert-based models applied at the microsite scale have potential for understanding localized relations and providing information for development of management recommendations at the site scale. Bayesian Belief Network models have been developed to identify habitat characteristics of survey and manage species at a microsite scale. These models typically use variables that are not available in a GIS framework but may help to define habitat associations or to direct surveys at finer scales. This approach also has been used as a method to evaluate management options for select survey and manage species. In addition, this type of modeling approach may provide an objective way to address species management questions and risk assessments, and may be used as an objective decision tool.

Current modeling approaches develop single-species models. This is because each survey and manage species is unique in its ecological requirements and distribution. However, considerable overlap may exist among species or groups of species. In these cases, models may be combined or aggregated to increase field sampling efficiencies in model calibration or model validation efforts.

Model-based approaches are often data intensive during the development, calibration, and validation processes. Therefore, information from multiple sources and scales is beneficial to this approach. Information used and acquired in model development will refine and enhance the survey and manage species data and knowledge base.

Information developed by modeling can contribute to refinement of the survey protocols and management recommendations or address specific distribution or habitat-association questions. In addition to improving the efficiency of targeting surveys, the habitat modeling process also can address information needs regarding association with LSOG forests, distribution relative to land allocation, and important habitat features that can be useful in designing site management prescriptions.

Potential benefits:

- Provides a broad-scale representation for the species based on current, often limited field observations that can be useful in directing other survey efforts.
- May lead to the generation of insights and hypotheses that result in efficient and increased acquisition of additional information for survey and manage species.
- Can incorporate multiple species by aggregating or integrating models for field calibration or validation.
- A spatial habitat model can be used as a tool to guide purposive surveys with the objective of finding new sites of target survey and manage species.
- Can provide objective means to evaluate species management questions.

Considerations and limitations:

- Modeling efforts currently limited by accurate species locations and field data.
- Without validation, resulting information can have limited usefulness for certain questions
- Need one model for each survey and manage species.
- Existing information may be too limited and contain potential biases for rare species (i.e., those species with only one known site).

Known-Site Survey Approach

Many species information needs may be met through an approach known within the NWFP survey and manage program as “known-site surveys.” This approach can be used to relocate previously reported sites, establish the current status of species at a site, and collect species-specific habitat information. The general focus is on collecting detailed habitat information that can be useful in the development of predictive models and management recommendations. This approach is particularly useful when considerable time has elapsed since information about the known site was collected, incomplete habitat information was collected, or establishing the current species status at the site is desired.

Initially this approach was directed to sites or locations where a survey and manage species had been previously reported. Experience in relocating these sites has shown that not all sites in the ISMS database are valid or "known." A better description would be "previously reported." In recent years, known-site surveys have been expanded to include documenting new sites of survey and manage species by using established known-site survey protocol. Another application of known-site surveys is to aid in habitat model calibration and validation. Surveys can be targeted at known and predicted locations to provide ground-based data for evaluating model predictions and uncertainty. Spatial habitat models also can be used as a tool to find new sites of the target species.

Known-site surveys are enhanced if consistent protocol is followed. Known-site survey protocols have been developed and tested and are currently being used to install and document plots where survey and manage species occur. Training field crews in the known-site survey protocol will ensure consistency in survey techniques and data collection and will provide benefits toward use of data for interpretation and analyses.

Potential benefits:

- May increase field crew efficiency by visiting sites previously identified as occupied.
- Permits targeting efforts on specific high-priority species and habitats.
- Efficient way to gather site-specific information on habitat and local populations.
- Provides a starting point to gather habitat data and to build information and a knowledge base that can be used in habitat modeling.
- Can incorporate multiple species into surveys by being opportunistic when survey and manage species are encountered.

Considerations and limitations:

- Lack of current and exact site location information may make relocating the "known" site difficult and time consuming.
- Many known-site locations in the ISMS database are not accurate enough to relocate the reported site, or the location information is too general.
- Known sites may not be representative of the full range of species locations or habitats.
- Because the likelihood of species detection varies considerably, the nondetection of species may be problematic and the reasons potentially difficult to identify; i.e., species no longer occupies the site, species is present but undetected, errors in site location information, or correctly finding the previously reported site.
- Information collected in such surveys cannot be used to infer values for population numbers of occupancies.

Purposive-Surveys or Expert-Search Approaches

The purposive survey or expert search is a knowledge-based approach that may be intuitive or explicit. It relies on the ability of experts to recognize and concentrate survey effort in potentially occupied or suitable habitats. The primary objective of purposive surveys is to increase the number of known occupied sites, usually for the rare survey and manage species, or for those that are poorly known, or with few reported

sites. This approach requires prior knowledge about suitable habitat or species-specific habitat associations, and the development of a successful search strategy through refinements based on observations at occupied and unoccupied sites. Spatial habitat models have been demonstrated to be an effective tool to identify areas to conduct purposive surveys and have resulted in documentation of many new sites for some target species. Informal intuitive models also may be used to target surveys in likely areas. Surveyors can visit sites where the species has been reported, develop a concept of suitable habitat, and then look in appropriate areas to find new sites. Purposive surveys are enhanced if the surveyor can establish the identity of the target species in the field. Substantial delays between collection and identification of species collections will make it harder for the surveyor to improve visual search pattern based on knowledge of occupied habitat.

Opportunistic surveys also may occur with this approach. If the surveyor is skilled in the recognition of other survey and manage species, then as those species are encountered in the field, locations can be recorded and data collected to build an information base.

The value of purposive surveys is enhanced if discovered sites are documented by using protocols for known-site surveys. Initially, the most important information about a species is its location. Providing accurate and detailed location information will enhance the value of the observation and allow crews to return to the site and collect more detailed site, habitat, and population information if necessary. Installation of a known-site survey plot at a discovered location for a target survey and manage species can be an efficient use of field time and provide consistent information on species' locations and habitats.

If the experts believe they have a considerable understanding of likely habitat, they might consider the stratified random-sampling approach discussed previously rather than a strictly purposive approach, and thus have the ability to make some statistical inferences from the data.

Potential benefits:

- Potentially an efficient strategy for finding additional sites, if the target species occurs in habitats that the expert generally associates with the taxon.
- Uses prior experience, expert judgment, and field observations to identify and then search potential habitat.
- Potential to opportunistically survey for other survey and manage species that may occur in similar habitats.
- Effective strategy for finding new sites when using a spatial habitat model to guide surveys.

Considerations and limitations:

- Difficult to objectively determine how representative discovered sites are of a species distribution. May lead to discovery of occupied sites in only a portion of a species' true range or suitable habitat conditions.
- Additional information and knowledge may be necessary to extend any information beyond the site-specific observation (e.g., modeling, additional probability surveys, etc.).

- When little information is known about the species, the expert search pattern may be equal to or only slightly better than random searching.

Research and Analytical Approaches

Additional information beyond that collected from field surveys may be needed to address persistence concerns, development of conservation plans, and site management. Research studies and a variety of analytical approaches can serve as tools to collect needed information, or provide approaches to analyze data across taxa and regional distributions. Some research and analytical approaches will necessarily be species specific to address identified or potential persistence concerns such as population genetic structure; others may include multiple-species analyses, even across taxa groupings. Studies can address specific questions and information needs as outlined in the framework. Not all species will need detailed research or study to reach final management decisions regarding species persistence. Indeed, one purpose of these approaches is to address uncertainty or incomplete information and find solutions to deal with information gaps.

Research and analytical approaches fall into five general categories that range from discovering needed biological and ecological information on individual species to examining broad patterns of species and habitat distribution. The categories below are not necessarily mutually exclusive, and some approaches may include components from different categories depending on the scale and complexity of the question.

Persistence concerns—Limited information is available on the life history characteristics of most survey and manage species. We have a poor understanding of their reproductive biology, dispersal characteristics, population dynamics, ecology, and response to disturbance or stand treatments. Knowledge of some or all of these attributes is typically used to aid in evaluating species persistence in conservation planning. For many species, understanding dispersal characteristics and impacts of habitat fragmentation and connectivity may be important in selecting suites of high-priority sites for management. Selection of species-specific studies must be driven with the same prioritization procedures as noted for other survey approaches within the *Strategic Survey Framework*.

Disturbance ecology and adaptive management—The forest landscape in the Pacific Northwest is dynamic, and its patterns have been affected by repeated disturbance events at different spatial and temporal scales. Forest species are adapted to these disturbance regimes and operate within specific ranges. Information is lacking on thresholds for most species, including survey and manage species, especially in relating the pattern of disturbance created by the harvest of old-growth forests over recent decades to historical distribution patterns of this habitat. In a more immediate sense, we poorly understand the impacts of local site disturbance on resident populations of survey and manage species. Thinning and prescribed burning are silvicultural tools for forest management throughout the NWFP area, so their effects on survey and manage species persistence is an important question. Disturbance actually might be necessary to improve or maintain habitat for some survey and manage species, such as developing openings for canopy-gap species. Understanding these disturbance effects and the response of survey and manage species will contribute to achieving the multiple objectives of the NWFP.

Habitat analysis and modeling—Habitat modeling has been discussed previously as an approach to efficiently target surveys in potential suitable habitat and for defining key habitat features for site management. Currently, two modeling approaches

(the potential natural vegetation model at the broad scale and the Bayesian Belief Network at the microsite scale) are being tested for strategic surveys. Many other habitat models and modeling approaches, however, are available or might be developed as part of research endeavors for consideration in strategic survey efforts. In addition to developing habitat models that predict species presence, modeling efforts also might focus on testing the relation of key environmental variables that have relevance to site management and species persistence. Although some habitat modeling efforts will necessarily be focused on single species, some efforts also might focus on multiple-species habitat modeling.

Risk analyses and dealing with uncertainty—For the foreseeable future, we will not have complete information to substantively address all persistence concerns for all survey and manage species. Management decisions will therefore be based on species information with a degree of uncertainty associated with them. How do we conduct scientific analyses of available information, develop options based on those analyses, and assign levels of risk or uncertainty so that managers are well-informed for making decisions? What type(s) of information carries the greatest weight or value toward making informed decisions? Answers to these types of questions will help in making scientifically based management decisions and be useful in prioritizing information needs for designing survey protocols and conducting studies. Decision-support tools are available or can be developed to classify uncertainty and risk.

Testing and improving survey protocols and designs—Conducting strategic surveys at the scale of the NWFP for nearly 400 species is unprecedented in scope and complexity. Survey protocols and designs should be tested and improved to effectively collect the information needed to contribute to informed, science-based decisions. Therefore, the strategic survey program of work includes testing of protocols for efficiencies and improving designs as needed. Protocol designs need to be flexible so that they can be modified as questions and information needs shift through time. Some protocols might need testing at small scales with one or few species before applying at broad scales with multiple species. Others might be tested with multiple species at small to broad scales to quickly test efficiencies. Developing ways to analyze the newly collected data from strategic surveys to address complex questions also should be a continuous part of the overall program of work.

Other Information-Gathering Approaches

There are other types of survey approaches. They include opportunistic surveys; acquiring existing information from museums, herbaria, and literature; and obtaining knowledge or information from species experts.

Opportunistic surveys can occur when a field crew or resource specialist encounters a survey and manage species while conducting fieldwork for some other purpose. If accurate and detailed location information is documented for the species location, then the site can be efficiently relocated if necessary. Opportunistic surveys can include the gathering of additional information as well and may include installation of a known-site survey plot according to protocol.

Early in the implementation of the NWFP, data and information on survey and manage species were acquired from museum and herbaria records, and literature review, and species experts. It may be that there is additional information on species available from these sources, depending on the objectives and questions to be answered. An example would be information for a species in category E to help determine if it occurs in the NWFP area.

Evaluating and Selecting Approaches

Several considerations influence the choice of strategic survey designs or methods for gathering information on survey and manage species. Primary considerations include efficiency, cost effectiveness, scientific credibility, legal defensibility, logistics, and implementation. Approaches should be evaluated to determine if they meet defined objectives for strategic surveys and provide relevant information to address questions.

Efficiency is an important consideration in meeting survey objectives. How successful will the approach be at gathering data to address the questions and identified information needs? Selection of the appropriate survey strategy requires evaluation of different approaches and methods relative to the ability to address the questions and information needs identified as priorities.

Cost effectiveness is another consideration. What is the cost of acquiring the information? Given there are approximately 9.6 milion ha covered by the NWFP, the selected designs or approaches must be cost effective. Evaluation of costs requires knowledge, or at least estimates, of actual field costs and estimates of the variability in the observations. Evaluation of cost efficiency should factor into planning and implementation of strategic surveys. The cost of acquiring information under each design or approach will be primarily qualitative during the early stages of strategic surveys. As more experience is acquired, more informed analyses of costs and efficiency can be conducted.

Scientific credibility is an important consideration to ensure that survey methods and results are acceptable to biologists, resource managers, and the public. Periodic review by statisticians, species experts, biologists, ecologists, and resource managers is recommended to evaluate the ability of the design and approaches to meet the stated survey and manage goals.

Legal defensibility is another consideration in selecting approaches and methods for strategic surveys. Surveys need to provide data in order to meet objectives and timelines for survey and manage strategic surveys as identified in the NWFP RODs (USDA and USDI 1994, 2001).

Detection of survey and manage species is a factor to be addressed in survey protocols and designs. It is assumed that the occurrence of survey and manage species essentially represents rare events in time and space. Many can be observed only for brief periods or only occasionally over extended periods. They also can be rare in space, with large distances between populations. These characteristics provide unique statistical challenges to the design of surveys that provide quantifiable estimates about the species.

Another consideration is the need for flexibility of the sampling design and methods of collecting data. Although there have been many calls for large spatial-extent surveys and inventories, few actually have been implemented. Consequently, few real-world examples exist to draw experiences from and use in design selection. Moreover, given the multiple objectives for strategic survey information, the approaches must be flexible and capable of modification owing to changing logistical constraints and program objectives, and adaptive in response to experiences gained by conducting surveys.

Logistics and operational factors are important aspects to consider when evaluating and combining different survey approaches to address the identified information needs. Access to sample sites may be a factor in developing sampling designs and field implementation. Protocols should be developed and implemented by field crews in order to provide basic data to meet the species information needs and provide information that can be used to refine the sampling design in subsequent years. The

availability of necessary expertise and resources to design and conduct field surveys, identify specimens, analyze data, and present results needs to be addressed. Essential elements to ensure data quality and scientific credibility are training of field crews to conduct surveys according to protocol and inspection of field plots and data collection to ensure protocols are followed and data-quality standards are met.

Anticipated Evolution with These Approaches

This framework anticipates that as the information needs and amount of information develop, the combination of approaches will evolve. When little is known of a species or its habitat associations, it is anticipated that greater reliance will be placed on the design-based approaches and known-site surveys. As additional information becomes available, greater reliance likely will be placed on model-based approaches, with associated design-based validation efforts. This evolution also will likely shift from the more general questions and information needs for a species to more highly specific and targeted approaches directed at species management and persistence questions.

Concluding Remarks

As emphasized earlier, conducting regionwide surveys for over 300 rare, old-growth forest species throughout the NWFP area is unprecedented in scope. The nature of the effort is made more complex by the initial lack of information for these poorly studied species that reside in taxa groups not typically considered in conservation planning. Key to success are (1) a well-organized survey program that focuses on relevant questions about species persistence and provides easily translatable information to develop science-based management guidelines, and (2) use of well-designed survey approaches and protocols followed by appropriate analysis and interpretation by expert agency biologists and resource managers.

Finally, it is important to remember that the original survey and manage guidelines were designed around an adaptive-management philosophy wherein known sites would be protected while new information on species was collected through field surveys. That new information would then be used to reevaluate species persistence concerns and need for the survey and manage mitigation, and to develop appropriate conservation management plans. This *Strategic Survey Framework* builds on those initial adaptive-management principles by outlining a flexible process for determining species information needs, setting management priorities to acquire the needed information, and selecting survey approaches to maximize efficiency and effectiveness of information gained.

English Equivalent

1 hectare (ha) = 2.471 acres

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Appendix: Survey and Manage Categories

This appendix summarizes the mitigation objectives, criteria for assigning species, and management direction for each of the six survey and manage categories. More detailed descriptions can be found in the ROD (USDA and USDI 2001: 6–14).

Category A (rare, predisturbance surveys are practical).

Objective: Manage all known sites and minimize inadvertent loss of undiscovered sites.

Criteria for assigning a species to category A include:

- The species is rare, and all known sites or population areas are likely to be necessary to provide reasonable assurance of species persistence, as indicated by one or more of the following:
  - Low number of likely extant sites and records on federal lands indicates rarity.
  - Species poorly distributed within its range or habitat.
  - Limited number of individuals per site.
  - Highly specialized habitat requirements (narrow ecological amplitude).
  - Dispersal capability limited relative to federal habitat.
  - Microsite habitat limited.
  - Reproduction or survival not sufficient.
  - Low number of sites in reserves or low likelihood of sites or habitat in reserves.
  - Habitat fragmentation that causes genetic isolation.
  - Factors beyond management under the Northwest Forest Plan (NWFP) affect persistence, but special management under the NWFP will help persistence.
  - Declining habitat trend.
- Predisturbance surveys are practical.

Management direction: Manage all known sites, survey prior to habitat-disturbing activities, conduct strategic surveys.

Category B (rare, predisturbance surveys are not practical).

Objective: Manage all known sites and reduce the inadvertent loss of undiscovered sites.

Criteria for assigning a species to category B include:

- Same criteria as category A, except that predisturbance surveys are not practical.

Management direction: Manage all known sites, conduct strategic surveys.

Category C (uncommon, predisturbance surveys are practical).

Objective: Identify and manage high-priority sites to provide for reasonable assurance of species persistence. Until high-priority sites can be determined, manage all known sites.

Criteria for assigning a species to category C include:

- The species is uncommon, and not all known sites or population areas are likely to be necessary for reasonable assurance of persistence, as indicated by one or more of the following:
  - A higher number of likely extant sites and records does not indicate rarity of the species.
  - Low to high number of individuals per site.
  - Less restricted distribution pattern relative to range or potential habitat.
  - Moderate to broad ecological amplitude.
  - Moderate to high likelihood of sites in reserves.
- Predisturbance surveys are practical.

Management direction: Manage high-priority sites, conduct surveys prior to habitat-disturbing activities, and conduct strategic surveys.

Category D (uncommon, predisturbance surveys are not practical or not necessary).

Objective: Identify and manage high-priority sites to provide for reasonable assurance of species persistence. Until high-priority sites can be determined, manage all known sites.

Criteria for assigning a species to category D include:

- Same criteria as category C, except that predisturbance surveys are not practical or are not necessary to meet objectives for species persistence because inadvertent loss of some undiscovered sites would not change level of rarity.

Management direction: Manage high-priority sites, conduct strategic surveys.

Category E (rare, status undetermined).

Objective: Manage all known sites while determining if the species meets the basic criteria for survey and manage standards and guidelines and, if so, to which category (A, B, C, or D) it should be assigned.

Criteria for assigning a species to category E include:

- The number of likely extant sites and records and survey information on federal lands indicates possible rarity of the species.
- Information is insufficient to determine whether survey and manage basic criteria are met or to determine what management is needed for a reasonable assurance of species persistence.

Management direction: Manage all known sites, conduct strategic surveys.

Category F (uncommon or concern for persistence unknown, status undetermined).

Objective: Determine if the species meets the basic criteria for survey and manage and, if so, to which category (A, B, C, or D) it should be assigned.

Criteria for assigning a species to category F include:

- The species is uncommon and the number of likely extant sites and records and survey information does not indicate rarity.
- Information is insufficient to determine whether survey and manage basic criteria (including whether there is a concern for persistence) are met, or to determine what management is needed for reasonable assurance of species persistence.

Management direction: Management of known sites is not required, conduct strategic surveys.

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