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Northern Spotted Owl Effectiveness Monitoring Plan for the Northwest Forest Plan

Joseph Lint, Barry Noon, Robert Anthony, Eric Forsman,
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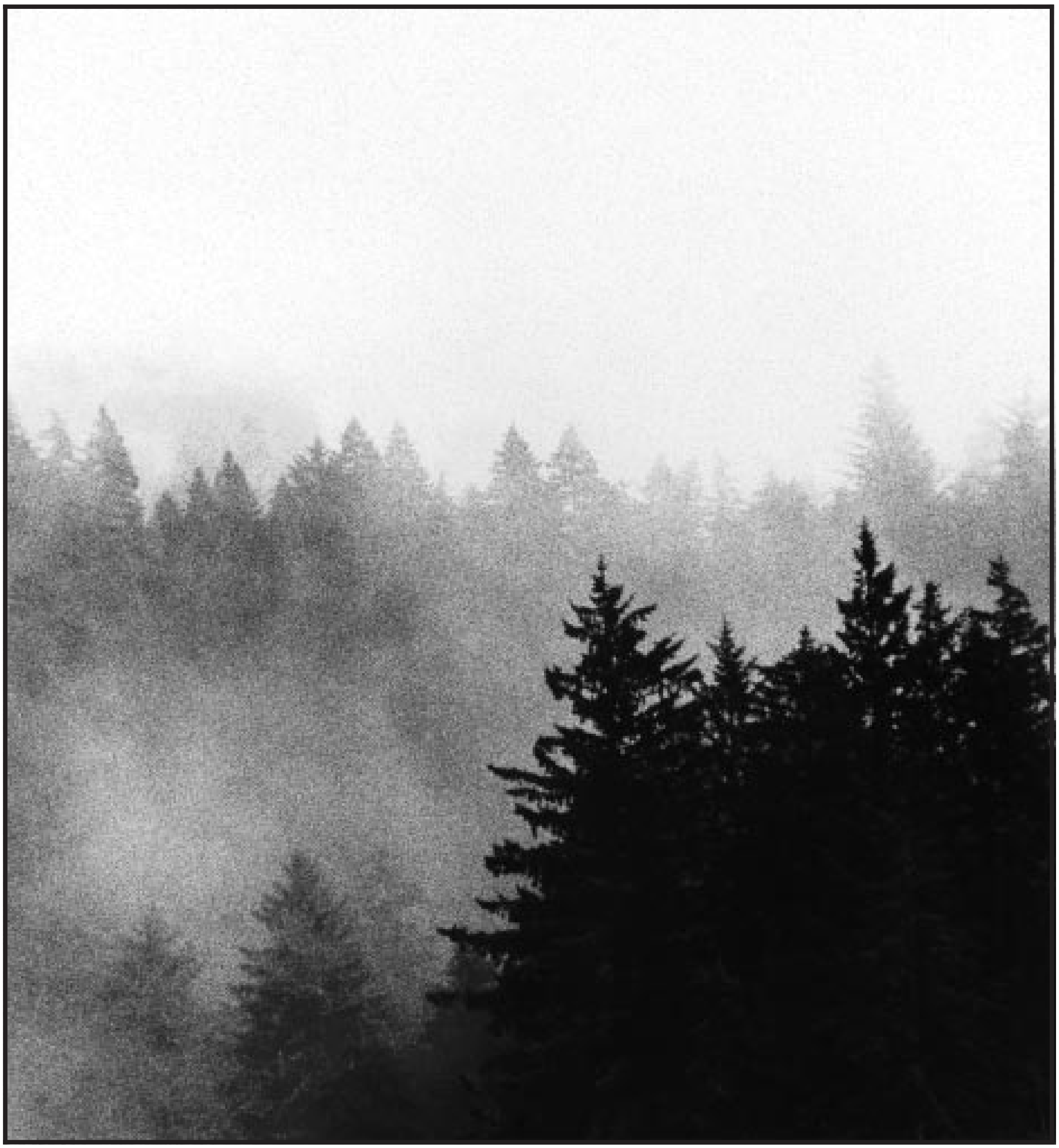

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Abstract

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This report describes options for effectiveness monitoring of long-term status and trends of the northern spotted owl to evaluate the success of the Northwest Forest Plan in arresting downward population trends, and in maintaining and restoring the habitat conditions necessary to support viable owl populations on Federal lands. It describes options to address monitoring questions, profiles population and habitat status, and points out areas of progress and concern. How population and habitat data from demographic studies would be integrated in the development of predictive models is described. A process to report status and trend results is presented that could provide a reference document for decisionmakers during periodic land use plan reviews.

Keywords: Northwest Forest Plan, effectiveness monitoring, northern spotted owl, suitable habitat, demographic study, remote sensing, GIS, landscape, stand scale, predictive model.

Preface

This report is part of a series describing the approach for monitoring effectiveness of the Forest Plan that have been approved by the Intergovernmental Advisory Committee. Other reports present the plans for monitoring late-successional and old-growth forests, marbled murrelet, and aquatic and riparian ecosystems. Future reports may address survey-and-manage species, biodiversity of late-successional and aquatic ecosystems, socioeconomics, and tribal resources. These reports follow the framework for effectiveness monitoring described in “The Strategy and Design of the Effectiveness Monitoring Program for the Northwest Forest Plan.” The purpose of this report is to present a range of options for monitoring the northern spotted owl from which the Federal agencies responsible for the Forest Plan can select an approach meeting their respective information needs given current and expected resource availability. This report responds to the assignment from the Federal resource agencies through the Intergovernmental Advisory Committee and incorporates responses to all comments and peer reviews, as requested. The options, recommended by the authors and the interagency Effectiveness Monitoring Team, have been selected for implementation in fiscal year 1998. Manuals, protocols, specific tasks, and annual funding allocations will be provided in individual agency work plans. All these documents, including manuals and work plans, will comprise the full set of guidance for conducting the effectiveness monitoring program for the Forest Plan.

Executive Summary

The purpose of the northern spotted owl effectiveness monitoring plan is to assess trends in spotted owl populations and habitat. Monitoring data will be used to evaluate the success of the Forest Plan in arresting the downward trends in spotted owl populations and in maintaining and restoring the habitat conditions necessary to support viable owl populations on federally administered lands throughout the range of the owl. Data from population and habitat monitoring in selected demographic study areas would be integrated in the development of predictive models and may provide further efficiencies in meeting the following objectives:

1. Assess changes in population trend and demographic performance of spotted owls on federally administered forest lands within the range of the owl.

2. Assess changes in the amount and distribution of nesting, roosting, and foraging habitat and dispersal habitat for spotted owls on federally administered forest lands.

In phase I of this two-phase plan, the ongoing population demographic monitoring would continue in selected areas. Data about the abundance and demographic performance of owls would be combined with habitat data from the demographic study areas to develop models to predict owl occurrence and demographic performance. Model validation and refinement would occur late in phase I. Testing of the models would determine the confidence levels associated with the model predictions. If the risk associated with model use is mutually acceptable to scientists and decision-makers, the models would be a primary monitoring tool in phase II.

In phases I and II, rangewide habitat conditions would be monitored to track changes in conditions by using owl habitat maps derived from the regionwide vegetation map. Forest class maps from the late-successional and old-growth forest monitoring effort also may be used in habitat monitoring for spotted owls.

Options for implementing population and habitat monitoring under phase I are provided. If the predictive models are in operational use, monitoring in phase II would rely less on demographic studies and move to a model-driven, habitat-based approach. Population and habitat monitoring would continue as implemented in phase I in the event that the predictive models are not implemented in phase II.

The estimated cost of implementing phase I (through 2002) of the monitoring plan includes the level 1 population option, level 2 habitat option, and development and validation of the predictive models and is expected to average about $2 million per year in the initial years. Implementation of predictive models would reduce the long-term costs of the monitoring program in phase II versus continuation of the demographic-based monitoring of phase I.

Summary reports detailing spotted owl monitoring activities and accomplishments would be prepared annually. A meta-analysis of owl population data from the demographic study areas would be completed every 3 years beginning in 1998. Rangewide habitat maps would be recompiled every 10 years in synchrony with late-successional and old-growth forest effectiveness monitoring plan schedules.

An interpretive report using the results of effectiveness monitoring for spotted owls would be completed every 5 years beginning in December 1999. It is recommended that a panel of science and management personnel be assigned the tasks of (1) reviewing the annual monitoring summary reports, and (2) preparing an interpretive report assessing progress in meeting the monitoring goals, objectives, and expected values for spotted owls under the Forest Plan. The report would address the monitoring questions, profile the state of spotted owl populations and their habitat, and point out areas of progress and concern. It would be a reference document for decision-makers during periodic land use planning reviews.

Contents

Introduction

Background

President Clinton directed the Forest Ecosystem Management Assessment Team (FEMAT) to develop long-term management alternatives for maintaining and restoring habitat conditions to maintain well-distributed and viable populations of late-successional- and old-growth-related species. The analysis of the FEMAT alternatives in a final supplemental environmental impact statement (USDA and USDI 1994a) led to adoption of the land-allocation strategy contained in the record of decision (ROD; USDA and USDI 1994b), commonly known as the Forest Plan.

A major goal of the Forest Plan is to protect and enhance habitat for the northern spotted owl *(Strix occidentalis caurina)*. The ROD explicitly states the need to develop a monitoring strategy for key components of the Forest Plan, including the northern spotted owl.

The purpose of the northern spotted owl effectiveness monitoring plan is to assess trends in spotted owl populations and their habitat relative to meeting Forest Plan goals. The cornerstones of the spotted owl effectiveness monitoring strategy are population and habitat assessments. The integration of data from population and habitat monitoring through predictive models (that is, owl population status predicted from the state of the habitat) should lead to further efficiencies in achieving the long-term monitoring goal and meeting the objectives given below. Sampling the population and habitat as described in this plan will ensure efficient use of agency resources and consistency of the information needed to conserve spotted owl populations.

The development of the effectiveness monitoring strategy for the northern spotted owl followed the guidelines for the design of a monitoring program as described in Chapter 2 of Mulder et al. (in press). The listing below provides specific reference points in the spotted owl effectiveness monitoring plan that involve each of the described steps.

Step 1—Specify goals. Refer to the following sections, “Introduction” and “Monitoring Questions.”

Step 2—Identify stressors and Step 3—Develop conceptual model. Refer to “Conceptual Model.”

Step 4—Select indicators. Refer to “Conceptual Model” and “Overview of Monitoring Approach.”

Step 5—Establish sampling design. Refer to “Overview of Sampling Methods.”

Step 6—Define methods of analysis. Refer to “Quality Assurance” and “Data Analysis and Reporting.”

Step 7—Ensure link to decisionmaking. This step was not fully developed during the preparation of the monitoring plan, but the underpinnings for this link are addressed in “Data Analysis and Reporting” and “Organizational Infrastructure.” It was assumed that this element of the monitoring program would evolve during the implementation phase as we better understand the indicators being monitored and can evaluate what response levels may suggest the consideration of changes in management direction.

Goal

This plan will evaluate the success of the Forest Plan in arresting the downward trend in spotted owl populations and in maintaining and restoring the habitat conditions necessary to support viable populations of the northern spotted owl on federally administered forest lands throughout the range of the owl.

Objectives

The objectives of the effectiveness monitoring strategy are designed to achieve the goal stated above.

1. Assess changes in population trend and demographic performance of spotted owls on federally administered forest lands within the range of the owl.

2. Assess changes in the amount and distribution of nesting, roosting, and foraging habitat (hereafter referred to as "habitat") and dispersal habitat for spotted owls on federally administered forest lands. Refer to USDA and USDI (1994a) for habitat definitions.

Monitoring Questions

The effectiveness monitoring plan will address a specific set of population-related questions, as listed below.

Population Questions

1. Will implementation of the Forest Plan reverse the declining population trend[1] and maintain the historical geographic distribution of the northern spotted owl?

a. What is the trend in rates of demographic performance (adult survival, reproduction, turnover, and the annual rate of change of owl populations)? Do these trends support a conclusion that the Forest Plan is working to achieve a stable or increasing population?

b. Can the status and trends in spotted owl abundance and demographic performance be inferred from the distribution and abundance of habitat?

(i) Can the relation between owl occurrence and demographic performance be reliably predicted given a set of habitat characteristics at the landscape scale?

(ii) How well do habitat-based models predict occurrence and demographic performance of owls in different land allocations (that is, late-successional reserves [LSRs] matrix, adaptive management areas from the ROD)?

Habitat Questions

The habitat monitoring portion of the effectiveness monitoring plan is focused on the following questions.

1. Is spotted owl habitat being maintained and restored as prescribed under the Forest Plan? This general question has two key components:

a. What is the trend in amount and changes in distribution of habitat, particularly in LSRs? Questions relevant to specific parameters and how they are changing through time, include:

(i) What is the structure and composition of habitat at a variety of spatial scales (nest stand, home range, watershed, provincial population)?

(ii) What proportion of the total landscape on public lands is owl habitat?

(iii) What is the distribution of sizes of habitat patches?

(iv) What is the distribution of distances (connectivity) among habitat patches?

(v) What are the primary factors leading to loss and fragmentation of habitat?

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[1] In the short term (5 to 8 years), insights into population trend will be limited to direct measures and inferences from the demographic study areas.

b. What is the trend in amount and distribution of dispersal habitat, particularly in the matrix? Questions relevant to specific parameters and how they are changing through time include:

(i) What is the structure and composition of dispersal habitat at the home range and landscape scales?

(ii) What proportion of the landscape represents dispersal habitat? How is it changing through time?

(iii) What is the distribution of distances (connectivity) between dispersal habitat patches?

(iv) What are the primary factors leading to dispersal habitat changes at home range, population, and landscape scales?

Conceptual Model

General Discussion

Overview—An initial step in the monitoring task is to select indicators that reflect the underlying processes governing the dynamics of a species' populations. Indicator selection is facilitated by first developing a conceptual model (see discussion in Barber et al. 1994; Mulder et al., in press). The conceptual model outlines the interconnections among ecosystem processes (key system components), the structural and compositional attributes (resources) characterizing the processes, and how the state of the resources affects population dynamics. The model should demonstrate the resources that directly, and indirectly, support the population. Given the prospective nature of this monitoring program, the model should emphasize how resources are affected by stressors and the anticipated population responses to these stressors. The model also should indicate the pathways by which populations accommodate natural disturbances and how they demonstrate resilience to such disturbances. A framework to guide model development is to link ecosystem process and function to measurable components of the resources (that is, structural and compositional attributes). Changes in resource value, in turn, can be used to make predictions of expected biological response (refer to fig. 7 in Mulder et al., in press).

Measurement of and inference to biological systems are affected by the scale of observation. To determine the appropriate scale(s) of indicator measurement, the temporal and spatial scales at which processes operate and populations respond therefore must be estimated (at least to a first approximation) and clearly identified in the conceptual model. Given the plurality of scale phenomena affecting most populations, the most useful conceptual models will have a hierarchical structure; that is, a given structural or compositional characterization of resources in the model will reflect population processes operative at faster temporal and smaller spatial scales, thereby implying the constraints operative at larger scales.

The indicators are the attributes that directly characterize the state of the population, or characterize the structural and compositional resources that directly determine population status. Indicators subsequently selected for measurement reflect known or suspected cause-effect relations to population dynamics. The likelihood of choosing appropriate indicators is greatly improved if the conceptual model thoroughly characterizes the ecosystem's dynamics and reflects stressor inputs. A satisfactory model therefore provides a justification, in terms of contemporary ecological principles and

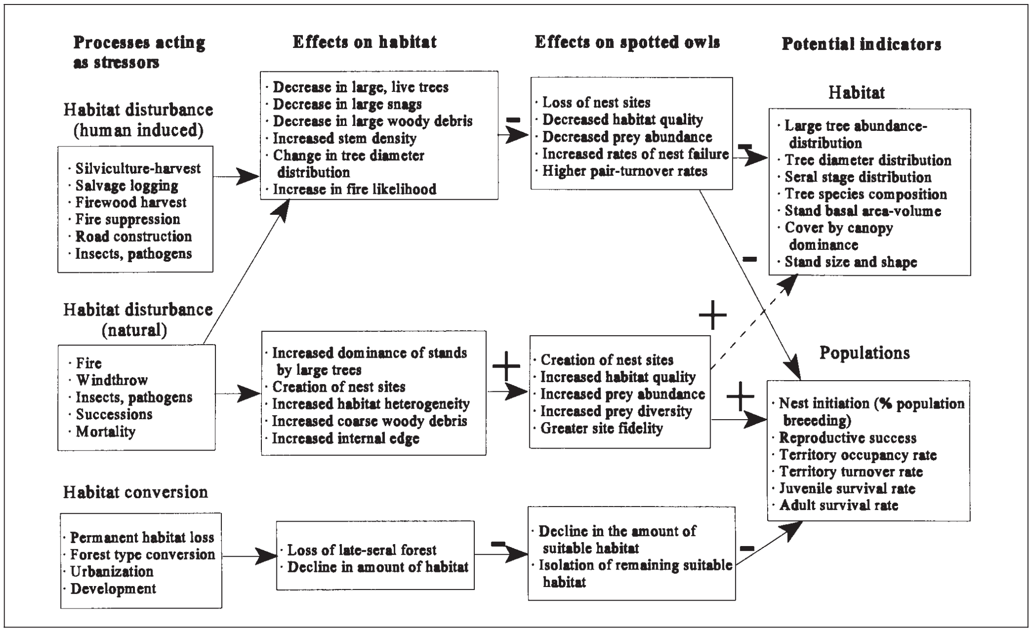

Figure 1—A conceptual model of the effects of natural and human-induced stressors on northern spotted owls at the home-range scale.

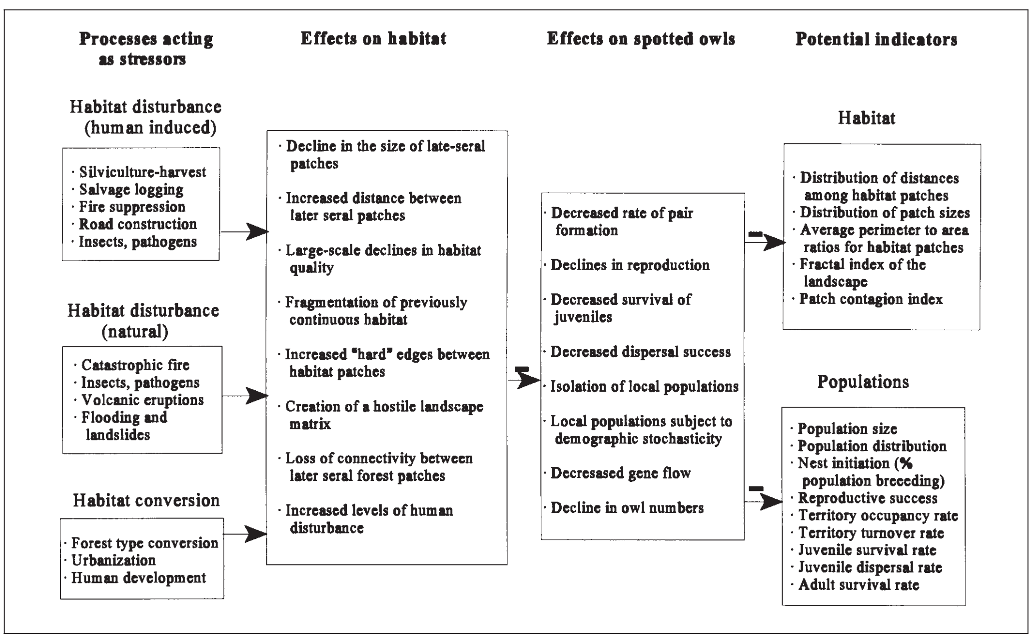

Figure 2—A conceptual model of the effects of natural and human-induced stressors on northern spotted owls at the landscape scale.

theory, for the indicator(s) selected for monitoring and how knowledge of the status and trend of the indicator reflects underlying process, function, and population response. In most cases it will be sufficient to model a restricted, but relevant, component of the ecosystem's resources. Thus, a complete model of an ecosystem is seldom necessary to proceed with a reliable effectiveness monitoring program.

Indicator criteria—On the basis of the conceptual model (described below) and the characterization of its central components, candidate population indicators were proposed for monitoring and selected on the basis of years of field work (summarized in Forsman et al. 1996). At this point, the primary criteria for indicator selection included consideration that the indicator:

- Reflects fundamental population processes and changes in stressor levels (that is, habitat change)
- Is representative of the state of the population
- Is measurable and quantifiable

We were able to narrow the list of candidate habitat indicators by building from years of research about the ecology and life history of spotted owls (literature reviewed in Noon and McKelvey 1996). In that process, we focused on indicators with the following properties:

- Their dynamics would parallel the dynamics of the species' populations
- They would reflect a rapid and persistent response to change in the state of the environment
- An accurate and precise estimation is possible (that is, a high signal-to-noise ratio)
- There is a high likelihood of detecting a change in the magnitude of the indicators given a change in the state of the ecosystem
- They would demonstrate a low level of natural variability, or additive variation, and changes in their values can readily be distinguished from background variation
- Measurement costs are not prohibitive

Application to the Northern Spotted Owl

The conceptual models developed for the spotted owl focus on habitat change (both loss of area and fragmentation) as the prime determinants of the species' population dynamics at this time. (The rationale for the decision to focus on habitat change as the key stressor is based on dozens of scientific publications, recently reviewed by Noon and McKelvey [1996]; see also the spotted owl conceptual model example in Chapter 3, Mulder et al. [in press].) We developed models at two spatial scales. One model focuses on habitat change (stressor) processes relevant at the home range scale, a meaningful scale in the context of the dynamics of individual pairs of owls (fig. 1). The other model focuses on changes in habitat pattern at the landscape scale (fig. 2). At this scale, habitat change affects the size, and thus of likelihood persistence of local populations, and the connectivity among populations.

For both models, possible indicators are in two broad categories—habitat and populations. This was done (1) to document the well-established relation between habitat change, at a variety of spatial scales, and the dynamics of owl populations; and (2) to suggest the list of habitat variables that may serve as surrogate indicators once habitat-based models are developed (see “Overview of Monitoring Approach”).

At the home range scale (fig. 1), habitat stressors are affecting the birth and death rates of individual owls. The consequences of habitat change at this scale can be assessed directly by measuring various demographic rates, or indirectly by measuring habitat attributes correlated with variation in these rates. Both approaches are appropriate, but direct measures of population attributes are clearly less ambiguous. For the near term, we recommend a continued focus on direct measures of population attributes. Specifically, we propose that monitoring efforts focus on precise and accurate estimates of adult survival rate by using capture-recapture methods (see details in Forsman et al. 1996 and appendix A). We emphasize adult survival rate as the most relevant indicator of population status because (1) variation in this rate most affects changes in population growth rate (Lande 1988, Noon and Biles 1990), and (2) it is responsive to habitat change at the home range scale (fig. 1).

The habitat indicators (variables) associated with population responses at this scale also are listed (fig. 1). As the focus of monitoring moves from a population-based to a habitat-based program, these are the variables likely to be used as input to the predictive habitat models applicable at this scale (see discussion in “Overview of Monitoring Approach”).

A second conceptual model addresses the landscape scale, focusing on stressors affecting local populations and the interactions among these populations (fig. 2). At this scale, habitat change affects not only dynamics of local pairs of owls but also connectivity among local populations. Attributes such as habitat patch size, shape, number, and distribution determine the connectivity and stability of local populations. The population consequences of habitat change at the landscape scale are ultimately the same as at the home range scale, even though the mechanisms driving the change are different (compare fig. 1 with fig. 2). Many of the possible population indicators at this scale could, in theory, be the same as those recommended at the home range scale. In practice though, landscape-scale habitat variables will probably be of insufficient resolution to predict population response at the home range scale.

For the near term, we recommend that inferences to the viability of the total spotted owl population be based on results from individual demographic studies. As a consequence, the primary indicator variables for monitoring at this scale also will be demographic rates from the individual studies. As was done in late 1993, inferences about the status of the owl population throughout its range will be based on a collective meta-analysis of data from all demographic study areas (Burnham et al. 1996). Thus, until reliable habitat models are developed to predict population status and trend at a landscape scale, we propose a continuation of population-based monitoring.

The transition from a population- to a habitat-based monitoring program at this scale will depend on the assessment of a different set of habitat variables (fig. 2). This difference arises because the processes affecting regional population dynamics are driven by different types of habitat relations. Here, the relevant population-habitat relations arise from the geometric pattern of habitat assessed at a population scale of resolution. Thus, habitat models applicable at the landscape scale will be more extensive but will predict population status with less resolution than models applicable at the home range scale. Relevant population-level indicators at this scale are population size and distribution (fig. 2).

In summary, the conceptual models document the relations between habitat dynamics and population response at two spatial scales. Until reliable habitat-based predictive models are developed, we recommend monitoring at the population-level by continuing the demographic studies. At the same time, we propose an active research effort to develop predictive models relating population dynamics to habitat variation at the home range scale and the landscape scale. This parallel research effort is necessary to move to a largely habitat-based approach to monitoring spotted owls. For the most part, landscape-scale models will be based on habitat attributes estimated from remotely sensed data. Home range-scale habitat models will rely on low-level aerial photography and ground plots to estimate the relevant variables. Because landscape-scale models make simplifying assumptions about habitat quality at the home range scale, both types of predictive models are necessary.

Overview of Monitoring Approach

General Description

We propose to develop and implement a long-term effectiveness monitoring program for spotted owls comprised of demographic studies, habitat assessment, and predictive model development, that relates demographic variability to habitat variation at the landscape and home range scales (fig. 3).

The plan will be implemented in two phases. In phase I, the ongoing demographic monitoring of the territorial portion of owl populations will continue in selected areas through mark-recapture techniques. These methods yield detailed information about demographic performance and annual rate of population change (Burnham et al. 1996). In the latter part of phase I, data about the occurrence and demographic performance of owls will be combined with information about habitat characteristics (structural and composition aspects of the dominant vegetation) from the demographic study areas. The combined data sets will be used to develop predictive models of owl occurrence and demographic performance based on observed habitat characteristics.

Habitat conditions also will be determined throughout the range of the owl to provide a means for tracking changes in habitat condition at the landscape scale. These estimates will require the compilation of vegetation conditions across the range of the owl into a geographic information system (GIS) format. Selected attributes from the vegetation map will be used to derive an owl habitat map. The forest class map from the late-successional and old-growth forest effectiveness monitoring plan also may be used in constructing the owl habitat map (see Hemstrom et al. 1998).

Phase I will culminate with model validation based on data collected from outside the demographic study areas in selected validation sites. Validation sites will compare the observed occurrence of owls with those predicted from the habitat models. Habitat condition initially will be estimated for selected model-validation test areas by a probability-based selection of sites from the rangewide habitat map. The models will be refined and evaluated for operational monitoring during phase II.

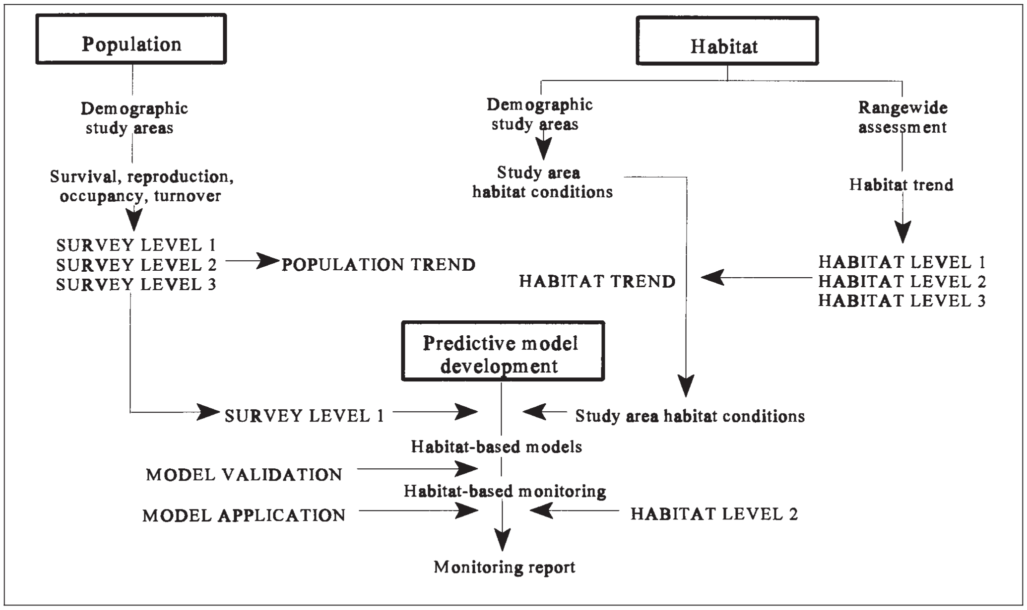

Figure 3—Components of the northern spotted owl effectiveness monitoring plan.

If the predictive models produced in phase I prove adequate (that is, provide predictions with an associated risk that is mutually acceptable to scientists and decision-makers), they will replace the intensive owl surveys and multiscale habitat work of phase I. As a result, phase II monitoring will rely less than phase I on mark-recapture techniques to estimate demographic performance. At least four of the demographic study areas would be continued beyond phase I, however, to maintain a direct link to the population status and trend through an annual check of demographic parameters. If the habitat-based models do not predict owl occurrence with acceptable reliability, phase I activities will continue; that is, monitoring of population trends of spotted owls in the demographic study areas would continue as the primary effectiveness monitoring strategy until the models are improved and the desired prediction accuracy is achieved, or an alternative monitoring strategy is developed. Likewise, if the rangewide habitat monitoring effort does not provide data of satisfactory resolution to track trend, then the habitat monitoring element will track changing conditions by demographic study area until rangewide effort is operational or another habitat monitoring strategy is adopted.

Selection of Monitoring Methods

The landscape- and home range-scale conceptual models for the spotted owl yielded a set of possible monitoring indicators for habitat and population assessment. We developed a list of alternative monitoring methods with the potential to address the indicator data needs. Each monitoring method was evaluated relative to its capability to yield data about the indicators. Tables 1 and 2 display the results of the evaluation of the alternative methods for owl population monitoring and rangewide owl habitat monitoring, respectively.

Population monitoring—The capability of a monitoring method to provide data about vital rates for individual owls was considered key to whether a method would meet the indicator monitoring needs identified in the conceptual models.

Table 1—Comparison of alternative methods for spotted owl population monitoring

Method name	Method capabilities for monitoring conceptual model indicators							
	Determination of:							
	Territorial owl population		Rates for individual territorial owls					
	Size	Geographic distribution	Reproduction	Occupancy	Survival	Turnover	Support for model development	Extrapolate results
Demographic study area mark-recapture studies	Yes[a]	Limited to province inference without model	Yes	Yes	Yes	Yes	Yes	Assumed range and province level
Random census plot - vocal lure	Yes[a]	Yes	No	Yes	No	No	No	Yes, range, province level
Density areas-100% habitat survey	Yes[a]	Limited to province inference	No	Yes	No, unless banding	No, unless banding	Possible for occupancy only	Limited, no confidence limits

[a] Estimation of population size possible through extrapolation by using habitat capabilities models.

Table 2—Comparison of alternative methods for spotted owl habitat monitoring

Method Name	Method capabilities for monitoring conceptual model indicators					
			Determination of:			
	Spatial scale analysis[a]	Geographic distribution analysis	Proportion of total landscape in habitat	Range of habitat patch sizes	Range of distance between patches	Extrapolation of results
Rangewide coverage	Yes	Yes	Yes	Yes	Yes	Complete due to total coverage
Demographic study areas	Yes[b]	No	No	Yes	Yes	Limited inference
Random blocks[c]	Yes[b]	Yes	Yes	Yes	Yes	Yes, depending on sample stratification
Current vegetation survey plots	No	Yes	Yes	No	No	Limited due to unstratified sample

[a] Habitat parameters may be summarized at a variety of spatial scales, including land allocation, administrative unit, physiographic province, and the range of the spotted owl.

[b] Extrapolation to the rangewide scale will be weak.

[c] Large landscape blocks >40,000 acres.

Three alternative methods for monitoring spotted owl populations were evaluated. The first, based on mark-recapture methods, would provide detailed estimates of demographic rates and the annual rate of population change (see Franklin et al. [1996] and Raphael et al. [1996] for methods and rationale). The second alternative method is based on repeated counts in randomly selected census plots and would provide estimates of rates of population change and rates of change in occupied habitat. The third method, density study areas, would require a total count of individual territorial owls in a multiple-township area and also would provide estimates of rate of population change and change in occupied habitat.

Mark-recapture methods are currently being used to monitor territorial owl populations in the Pacific Northwest (see Forsman et al. 1996). The studies provide estimates of rates of survival, reproduction, and turnover, as well as detailed data about location of nests, roosts, and habitat conditions at nest sites. Data about survival and reproduction are used to estimate the annual rate of population change and to investigate trends in reproduction (Franklin et al. 1996).

Bart and Robson (1995) suggest that a random survey using the vocal lure technique (calling for owls) could be done for considerably less money over broader areas than the intensive mark-recapture approach. The results can be used to estimate rates of population change, but not to estimate rates of survival, reproduction, or turnover.

The density study area approach has been used in the demographic study areas for several years. The density-estimate method assumes a 100-percent survey of a land unit of about 80,000 to 250,000 acres. In each density study area, observers record the number and location of all owls encountered in repeated surveys during a single season. Density areas are resurveyed annually. Several existing demographic study areas have density study areas within their boundaries; thus, data already exist that can be explored further.

From the comparisons in table 1, it is evident that only the mark-recapture method within demographic study areas will satisfy the array of indicator data needs. It also is the only method that will provide the option to pursue predictive model development, which is a key option within the overall spotted owl monitoring strategy. Given the 1990 listing of the northern spotted owl as a threatened species under the Endangered Species Act of 1973, as amended, we consider estimates of the demographic rates to be key elements of an effectiveness monitoring plan for the spotted owl at this time. We therefore propose that the primary sampling method for effectiveness monitoring should be continued mark-recapture studies in the demographic study areas.

An additional consideration for population monitoring, supported by northern spotted owl effectiveness monitoring subgroup members and several reviewers, is the use of an independent estimate of population trend for comparison with the results from the demographic studies. An additional, scientifically credible method would provide an independent, empirical assessment of the estimated population trend to compare with observed demographic parameters. For example, declines in survival and reproductive rates discerned from demographic studies should be reflected in declines in number of owls encountered during repeated surveys. We recognized both the random census plot and density study area methods as having the potential to provide the independent estimate of population trend.

To evaluate the use of an extensive survey (random census plot) to obtain an independent estimate of population trend, we asked professional statisticians to design a sampling protocol based on the vocal lure technique (Ramsey and Lesser 1995). Their work provided the subgroup with basic insights into possible survey designs and the utility of repeated counts in randomly selected survey "plots."

The sampling approach proposed by Ramsey and Lesser (1995) is based on a two-stage sampling framework. A random set of primary sampling units (PSUs) would be drawn from a given area (for example, province, state, entire owl range). Each PSU is about 100 square miles and contains about 100 secondary sampling units (SSUs). Within each PSU, a fixed number of SSUs would be randomly sampled. The SSUs would be screened for suitable habitat, and qualified SSUs (for example, >20 percent suitable habitat) would be sampled by establishing survey points such that all areas in each SSU would be exposed to owl calls. Each SSU would be sampled once a year, and all owls responding would be recorded.

Ramsey[2] subsequently provided an estimate of the sample intensity (the number of SSUs to be surveyed) required for geographic-based sampling strata, so that the population trend estimate was within 20 percent of the correct value 95 percent of the time. For the single, rangewide stratum, the estimate was about 700 SSUs. To obtain separate estimates for individual states would require about 1,800 SSUs: 900 in Washington, 600 in Oregon, and 300 in California. To obtain estimates within 20 percent of the true value for individual physiographic provinces would require nearly a complete survey of all SSUs in some of the small provinces.

Annual sampling of SSUs would provide point estimates of the percentage of the SSUs occupied. These estimates could be averaged for individual PSUs, provinces, states, or for the range of the owl. Considerable uncertainty exists, however, about the sample size of survey units and number of years of survey required to detect small changes in population trend. If the rate of population change is small (say 1 percent per year), and owl detection rates differ among years, many years would be required to detect a <5-percent rate of change in the population. If the rate of change is large (>5 percent per year), however, the method would probably detect a significant downward trend in only a few years.

Because of uncertainty about the statistical power of the census plot approach, we recommend additional estimates of the statistical power of the method and its cost effectiveness. Likewise, further analysis should be conducted on the efficacy of the density study areas to provide an independent estimate of population trend. Once these additional analyses are completed, the adoption of a method to obtain an independent estimate of population should be given further consideration.

Habitat monitoring—The dynamic changes in vegetation structure and composition of forested ecosystems in the Pacific Northwest reflect the underlying biotic and physical driving forces, including timber harvest and other human-caused sources of disturbance. For this document, we assumed that knowledge of vegetation structure and composition (amount and distribution) of habitat allows reliable prediction of spotted owl occurrence and possibly the demographic performance of spotted owls. We acknowledge, however, that the expected ratio of species viability with attributes of the

[2] Personal communication. 1997. Fred Ramsey, professor, Oregon State University, Corvallis, OR 97331.

vegetation will not be 1:1. As a consequence, regular, local validations of assumed relations between vegetation structure and composition (habitat) and species viability still may be required. Despite this important caveat, accurate and timely monitoring of changes in the status and trends of vegetation (habitat) should provide a reliable early warning system to eventual changes in the population viability of spotted owls.

Changing from a species-based to a habitat-based monitoring program offers several advantages:

- Habitat monitoring can build from existing forest inventory programs.
- Estimating the trends in vegetative structure and composition represents a prospective, as opposed to a retrospective, approach to ecological monitoring.
- Monitoring vegetation change is more cost-effective than directly monitoring populations of all the possible species for which public land management agencies are responsible.

Some possible, but unverified, limitations to a strictly habitat-based approach to monitoring may exist that must be addressed in designing a monitoring program. Such limitations may include:

- Some unknown proportion of the variation in species' population dynamics may not be driven by changes in habitat amount and distribution (for example, population fluctuations due to behavioral and age-related influences).
- Changes in habitat may not predict population responses to other stressors (for example, environmental toxins, changing environmental conditions, and competitive interactions).
- On the basis of the above two limitations, a strictly habitat-based monitoring program may have limited ability to predict changes in species viability and distribution.
- Existing vegetation inventories do not measure all the attributes relevant to the status and trends of spotted owl populations and their primary prey.
- Vegetation variables measured at the macro scale may not directly correlate to important factors affecting population dynamics of a species at a more local scale. These factors may ultimately be affected by the vegetation but act indirectly through more than one trophic layer. This is particularly true for carnivores where the relation to habitat can be indirect. For example, habitat determines the abundance and availability of the prey population that, in turn, can affect owl populations.

Habitat monitoring for spotted owls will consist of two separate, but related initiatives. One is tied directly to each of the demographic study areas. Stand-specific vegetation classifications and habitat evaluations will be completed in each study area. Habitat assessments of demographic study areas will be based on forest plot data, stand description information, and standard aerial photography to develop stand structure and composition attributes for spotted owl habitat. These data will be used with the population data to assess the relations among varying demographic responses and varying habitat conditions at the forest stand, owl home range, and watershed scales. These relations will form the basis of the predictive models (phase I).

The second habitat assessment will estimate baseline, rangewide spotted owl habitat conditions and track change in habitat conditions over time. As shown in table 2, the rangewide coverage, demographic study areas, random blocks, and current vegetation survey plots were evaluated as potential methods for accomplishing the habitat indicator monitoring. The rangewide coverage and random block methods ranked highest because of their capabilities for spatial analysis, portrayal of geographic distribution of habitat, and analysis of patch statistics. Both methods rely on the same base vegetation map, which will be developed from satellite imagery. The rangewide coverage method was chosen over the random block method because it uses the entire data set, not just a sampling of a subset. This is a case where the current analytical tools permit the assessment of the universe of data, thus eliminating the need to stratify and sample the data, which would require statistical analysis to describe the precision of the estimates and would be more expensive.

The rangewide coverage method will employ a temporal sequence of habitat maps derived from the rangewide vegetation map and supplemented by the forest-class map produced under the late-successional and old-growth forest effectiveness monitoring plan (Hemstrom et al. 1998). From the derived maps, the baseline for rangewide habitat condition will be established and periodically reassessed to describe habitat condition and trend. This will allow tracking of the amount of habitat and dispersal habitat at a variety of spatial scales. It also will provide information for characterizing habitat conditions for areas where the predictive model will be tested as part of the validation phase.

The following variables are a minimum set of attributes thought to influence presence and abundance of northern spotted owls at the landscape scale and to be monitored rangewide:

- Distribution and area of the forest corresponding to northern spotted owl habitat and dispersal habitat
- Frequency distributions, by area size-class, of habitat patches
- Frequency distributions of distances between habitat patches

These parameters may be further summarized at a variety of spatial scales including land allocation, administrative unit, physiographic province, and range of the northern spotted owl. In addition, this inventory of habitat conditions can provide the basis for assessing the degree of overlap of northern spotted owl habitats with those used by other wildlife species associated with late-successional forests. These data also may afford opportunities to explore a more ecosystem-oriented approach to managing late-successional forests for wildlife. Refer to “Overview of Sampling Methods”, below, for additional information about habitat sampling.

Predictive modeling—To make the transition from phase I population-based monitoring for spotted owls to a habitat-based program (phase II) will require an intensive period of habitat model development (fig. 4). We recognize this task to be primarily one for research, but it is also a necessary step to move from phase I to phase II of the effectiveness monitoring strategy.

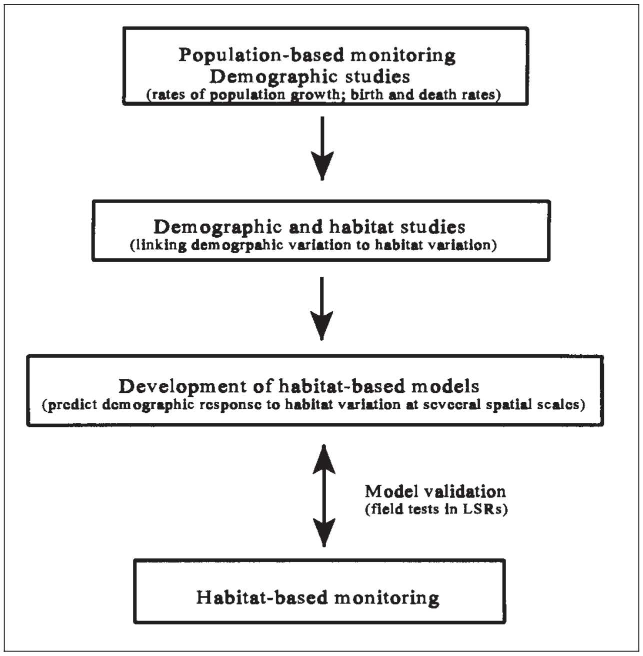

Figure 4—Relation of population and habitat studies to habitat-based predictive models for effectiveness monitoring of northern spotted owls.

To accomplish this transition, we must identify those aspects of vegetation structure and composition that have the greatest power and precision to predict the number, distribution, and demographic performance of owls at the landscape scale, as well as to explain the observed variation in demographic rates at a home range scale. This task will require characterizing the vegetation at a variety of spatial scales in the existing demographic study areas. The combination of spatially referenced data from both the owl demographic studies and mapped vegetation attributes provides the fundamental data for the model-building phase. The degree to which these models explain the observed variation in owl distribution and demographic performance will estimate the certainty with which habitat variation predicts population performance and stability. Explained variation is thus a direct measure of the confidence we have in habitat as an appropriate monitoring surrogate for population performance.

In addition, validating model predictions by independent field surveys is essential; that is, the models will be used to predict owl population response, which must then be verified by direct field measurement of owls from several landscapes with different population levels (fig. 4). Validation testing will use the rangewide habitat map derived from the regionwide vegetation map. Once reliable models are developed, existing habitat conditions across extensive landscapes such as LSRs, can be assessed and expected owl occupancy, distribution, or demographic performance predicted depending on which predictive level (see “Overview of Sampling Methods”) of effectiveness monitoring is implemented.

Population data from the demographic studies and habitat information from companion studies on vegetative characteristics at these sites will provide the data needed to "model" patterns of spotted owl occurrence and demographic performance to home range and landscape characteristics of the vegetation. Provided the models are field tested and shown to be predictable at a level of uncertainty (associated risk) mutually acceptable to scientists and decisionmakers, emphasis will shift from mark-recapture studies to increased reliance on monitoring of owl habitat and use of predictive models to indirectly estimate the occurrence and demographic performance of owls.

Overview of Sampling Methods

Population Sampling

Phase I: Monitoring levels—The experimental design of the demographic study areas is crucial for estimating owl birth and survival rates. This is important because the individual vital rate estimates provide data about population indicators for the conceptual models. These data will be used in the population meta-analysis and as input to construct the predictive models.

The alternatives considered for locating the demographic study areas across the landscape were a stratified, random placement of the demographic study areas or the existing pattern (nonrandom) of demographic study areas as described in Forsman et al. (1996). It was the consensus of the subgroup that the location of the areas described in Forsman et al. (1996) could be modified to provide a design for effectiveness monitoring. We also recognized that the data sets of 7+ years for these existing study areas would be beneficial to the monitoring program because they provided readily available data sets for analysis. Modifications to the pattern reported in Forsman et al. (1996) involved either increasing or decreasing the size of the areas and, in some instances, combining areas. The result was a nonrandom design of eight study areas.

In deciding which of the alternative demographic study designs to use, we examined physiographic province representation, ownership representation, major forest type representation, spectrum of ecological conditions covered, value of existing data sets to the monitoring effort, and capability to infer results to the province and rangewide scale. We also considered the advantages and disadvantages of starting anew with a stratified random sample as opposed to continuing with the ongoing studies. The basic question was whether the nonrandom design would provide the type of information needed to address population trend at the rangewide scale. In the meta-analysis of data from 11 demographic study areas conducted by Burnham et al. (1996), they assumed that the number, large size, and wide distribution of the 11 areas would allow extension of the statistical inferences beyond the specific areas to the range of the owl. We examined the design alternatives for each factor listed above and concluded that although the nonrandom demography placement method lacked the statistical support inherent in the random method, it was reasonable to expect the nonrandom design to provide data adequate to meet the effectiveness monitoring needs. In addition, the large, quality data sets associated with the existing demographic study areas provide a foundation for the monitoring program not present in the random design. Based on this reasoning, we selected the pattern of eight study areas as the entry-level option for population monitoring. This conclusion was supported by the knowledge that the eight areas had sufficient pairs of owls to assure continued low standard errors of the vital rate data comparable to the data from Burnham et al. (1996). Representation of the physiographic provinces also was similar to the Burnham et al. (1996) work.

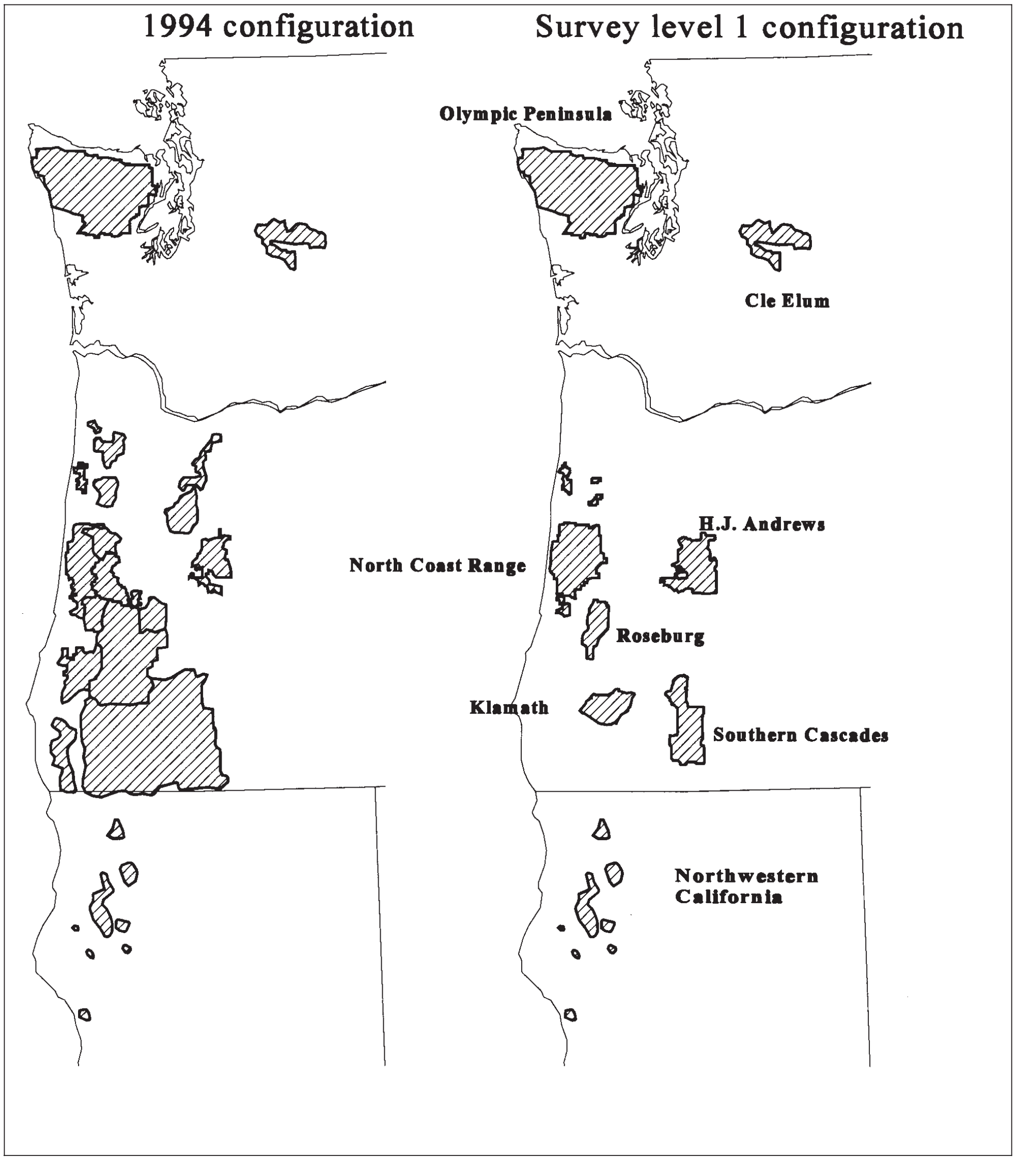

Figure 5—Comparison of the previous (1994) to the proposed (survey level I) configuration of demographic study areas that illustrates the differences in size and location of the study areas.

There was uncertainty about the adequacy of the coverage of the owl range with a design of less than eight study areas and the capability to expand the results of a metaanalysis to the range of the owl. As such, we were not able to support an option with fewer demographic study areas and still defend it as scientifically credible.

The eight demographic study areas selected as the monitoring sites under survey level 1 are shown in figure 5. Although these study areas do not cover all provinces or ecological conditions across the range of the owl, we believe they represent a sample of sites that spans a wide range of habitat conditions and represent the range of variation in demographic rates. The network of existing demographic study areas proposed under survey level 1 includes more than one study area in the Oregon Coast Range. We believe this is justified because those study areas represent different ownerships and management strategies (Bureau of Land Management [BLM] and Forest Service), and they will allow a more detailed examination of one area where the owl is thought to be particularly at risk because of past habitat loss.

Three alternative survey levels have been proposed that range from least extensive in coverage of ecological and ownership conditions and lowest expense (survey level 1), to more complete coverage of the owl's range and higher cost (survey level 3). Survey intensity is increased by increasing the number of demographic study areas.

Survey level descriptions—*Survey level 1:* Survey level 1 includes survey of spotted owls from eight demographic study areas. These areas are based on portions of the original long-term demographic study sites (Forsman et al. 1996). The eight areas are Olympic Peninsula (Olympic National Forest and Olympic National Park, Olympic Peninsula Province), Cle Elum (Wenatchee National Forest, Eastern Cascades Province in Washington), North Coast Range (Siuslaw National Forest and Eugene-Salem BLM, Oregon Coast Range Province), H.J. Andrews Experimental Forest (Willamette National Forest, Western Cascades Province in Oregon), Roseburg (Roseburg and Coos Bay BLM, Oregon Coast Range Province), Klamath (Roseburg and Medford BLM, Oregon Klamath Province), South Cascades (Winema and Rogue National Forests, Western Cascades Province in Oregon), and Northwestern California (Six Rivers, Klamath, and Shasta-Trinity National Forests and BLM, California Klamath Province). Refer to figure 5 for locations of these areas.

Survey level 2: Survey Level 2 monitoring includes the same areas proposed for level 1 with the addition of study areas in all the physiographic provinces not covered by level 1 sampling. Demographic study areas would be added in the following provinces.

1. Western Cascades Province in Washington

2. Eastern Cascades Province in Oregon

3. California Cascades Province east of I-5 in northern California

This scale of monitoring would provide a more complete understanding of the regional variation in demographic trends by having at least one demographic study area in each physiographic province described in the ROD (USDA and USDI 1994b).

Survey level 3: Survey level 3 monitoring includes the same areas as level 2 plus an additional four to seven demographic study areas to provide a more complete coverage of ecological conditions, land ownerships, and management conditions within the owl's range. For example, in Oregon, additional demographic studies would be initiated in the Western Cascades and Klamath Provinces. Such studies would allow comparisons among demographic performance of owl populations in regions and provinces, and between forest management strategies—both historical and present day. This effort would be the most comprehensive and rigorous of the proposed monitoring levels.

Phase I: Sample sizes and protocols—Minimal sample effort for any given demographic study area is constant across areas. Precise estimates from mark-recapture studies require large samples of marked owls. We recommend that sample sizes for individual demographic studies be ≥50 pairs of owls (100 individuals), with samples of 75 to 100 pairs preferable. These sample size criteria are satisfied for each of the eight demographic areas in the survey level 1 design.

Sampling procedures will follow existing protocols developed by scientists at the Forest Service's Pacific Northwest Research Station and U.S. Geological Survey's Biological Resources Division and other cooperators on the demographic studies (appendix A). These protocols have been developed, field tested, and refined by owl biologists for more than 20 years and represent the most efficient and cost-effective methods for monitoring owl populations.

Demographic parameters monitored in mark-recapture studies should include survival and reproductive rates by age-group and sex. From these data, the annual rate of population change can be estimated. Occupancy and turnover rates at historical owl sites in the demographic study areas also should be monitored because these variables may provide key information about the response of owls to variation in home-range scale and landscape-scale features. Established protocols for assessing survival, reproduction, occupancy rates, and turnover rates of spotted owls will be followed (appendices B, C, and D).

Phase II—Contingent on the development of reliable habitat-based models, we will shift from demographic-based monitoring toward use of predictive models to estimate the occupancy, distribution, and demographic performance of owl populations and how these are changing through time. A subset of reference demographic study areas, however, will need to be continued during phase II. These areas will represent a broad cross-section of the different ecological conditions and geographic areas within the range of the owl. They also will provide preliminary validation, in the sense of observed versus expected response, to the population predictions of the habitat model. We recommend that at least four demographic studies be continued beyond the end of phase I: Northwestern California, Roseburg, H.J. Andrews, and Cle Elum (refer to fig. 5).

Habitat Sampling

Demographic area habitat assessment—Habitat classification and mapping will be completed for each of the demographic study areas. To date, the habitat characterization has been conducted independently for each of the demographic study areas. As a result, there are differences in the measured attributes, classification standards, and resulting map products. Consistency of the vegetation classifications is important to the modeling that will follow, thus there is a need to resolve differences between the methods. The resolution of these differences may involve some resampling and reclassification of variables in some of the demographic study areas. The responsibility for completing this will be assigned to the leaders of the respective demographic studies. All reassessment and new classification efforts will follow the consensus standards developed during the resolution process.

The set of vegetation attributes that best characterize spotted owl habitat will differ by physiographic province and study area. Investigators will therefore first identify the key attributes in each demographic study area to be used to define habitat depending on presumed habitat relations in that province. The landscape-scale habitat maps will be based on attributes acquired from the regional vegetation map or specified for inclusion in subsequent versions of the vegetation map. This approach is essential so that more general predictive models can be built that apply outside the demographic study area boundaries.

Rangewide habitat assessment—The basic information needed for rangewide monitoring of spotted owl habitat is a set of map layers that collectively characterize spotted owl habitat and dispersal habitat. An overlay of map layers will allow the development of a GIS-compatible database used to describe amount and distribution of habitat in relation to land allocations or other geographic areas of interest. Once developed, the map would be updated periodically to track habitat change. Periodic updates of the map layers in the near term will allow the estimation of changes in amount and distribution of habitat over time resulting primarily from timber harvest and wildfires. Changes in vegetation due to forest succession are not expected to provide any significant changes in habitat condition for several decades. In the initial years of monitoring, detecting biologically significant changes in habitat condition will require periodic inventory at ≤10-year intervals. The map would be recompiled and habitat conditions reassessed in synchrony with the schedule for late-successional and old-growth (LSOG) effectiveness monitoring map product updates (Hemstrom et al. 1998).

The proposed approach to monitoring status and trends in northern spotted owl habitat is to build on existing map products of forest conditions and to develop others as needed. To provide the landscape-scale view of habitat conditions at different resolutions, the following three levels of habitat mapping quality were considered.

Habitat level descriptions—*Habitat level 1*: Habitat level 1 will use an updated version of the spotted owl habitat map produced as part of the FEMAT (1993) effort. The update will account for any harvest that has occurred in the interim or any habitat mapping efforts completed since the map was created. We concluded that this map lacks the accuracy needed to track owl habitat changes over time and is inadequate to meet the long-term goal and objectives of this monitoring plan.

Habitat level 2: The base map for level 2 will be the regionwide vegetation map. The use of the interagency Vegetation Strike Team's (Vegetation Strike Team 1995) standards for collecting a set of core habitat elements will enhance the map quality over level 1 and define the forest attributes used to characterize the imagery. Locations of sample plots (for example, current vegetation inventory; Max et al. 1996) will be coded to facilitate validation with stand-scale data and development of ancillary attributes. This product will provide the foundation for developing the spotted owl habitat map at the rangewide scale. An initial focus for implementing spotted owl habitat monitoring after the base map is produced will be to convene a small group of owl biologists to select the range of core elements that define habitat in each province or other relevant geographic areas. Areas meeting the desired habitat attributes, but exceeding the elevational distribution of the spotted owl in a given province, will be excluded.

Initial efforts to produce a spotted owl habitat map would focus on using the core elements to define spotted owl habitat. The core data elements likely to be most valuable are landcover class, cover type, year of stand origin, total tree crown closure and cover, forest canopy structure, tree overstory size class, and if available, tree species.

Validation and error checking of the initial maps for level 2 will be accomplished by comparing the satellite-based habitat map to other maps, including those developed by researchers about individual demographic study areas and those of the current interagency forest inventory.

Habitat level 3: Using additional stand-scale data about spotted owl habitat variables collected from measured forest stand plot data from the demographic study areas and from the grid-based plot-sampling system, the habitat level 3 effort will further validate and refine the habitat map produced in level 2. Changes in habitat due to timber harvest would be accounted for annually by using change detection or agency harvest records. This level of map resolution will most likely support a reliable owl habitat predictive model.

The recommended option for assessing the rangewide habitat conditions for the spotted owl assumes the recommended method for the late-successional and old-growth effectiveness monitoring program (Hemstrom et al. 1998) will be adopted. The monitoring of vegetation and habitat condition were purposefully tied to each other in the design of this portion of the overall effectiveness monitoring program. Both are based on the same vegetation map. The habitat map will be derived from either the vegetation map or attributes from the LSOG map. The rationale for the level of quality and resolution for the owl habitat map parallels that for the LSOG map. The existing owl habitat map from the FEMAT effort was the product of the construction of a composite map from many sources. It lacks an accuracy assessment and cannot be compared to any base maps produced from the latest technology. The recommended habitat level 2 will produce from the best suited, current technology a habitat map with known accuracy and the capability for repeated assessment of habitat trend.

New classifications of spotted owl habitat condition maps will be synchronized with the LSOG effectiveness monitoring plan (Hemstrom et al. 1998) schedule for map product updates.

Predictive Modeling

Development—Developing predictive models during phase I will be done in two steps. The first will search for relations between various measures of demographic performance and vegetative characteristics at the spatial scale of the home range, with samples centered on nests or activity centers. Habitat variables (the type, quantity, quality, and distribution of habitat resources) that appear related to demographic outcomes, or occupancy of owls, will be further examined to determine if habitat thresholds exist beyond which owl performance begins to decline. These thresholds, or measures of owl performance relative to habitat conditions, will then be used to develop predictive models of owl demographic performance at the scale of the breeding pair or individual territory.

The macroscale owl-habitat models will estimate relations between owl sites and landscape-scale variables. These variables will be estimated from the map(s) produced as part of the rangewide habitat assessment. The overall objectives will be to develop models that provide predictions of occupancy, distribution, and demographic performance of owls, based on vegetative characteristics assessed at a variety of spatial scales.

The recommended option is to pursue the development of habitat-based predictive models. The rationale is simple. Managers have requested that we focus on monitoring of the ecosystem rather than on specific species. Through modeling, habitat is the integrator for applying our knowledge of species relations with their environment into a single indicator. If successful, we would decrease emphasis on species monitoring and rely on habitat condition to provide us with knowledge of population condition and trend. Use of predictive models also would allow a more proactive management program and permit prospective views of likely change as opposed to retrospective assessments of what happened. The latter leaves us only the option to patch and recover as opposed to the prospective approach, which provides opportunity to set the trajectory for desired outcomes through model-driven insights of the future. A habitat-based monitoring program supported by predictive models also would be more cost efficient than a species-driven program. Although there is no guarantee that the first generation of models would yield predictions with levels of certainty adequate to meet the comfort levels of decisionmakers, the benefits that would accrue and the prospects for success in the model arena suggest that we must at least try.

Validation—After developing the predictive models, the next step will be to test them in areas outside the demographic study areas. Such comparisons will help determine to what degree the study areas represent the physiographic provinces, forest types, land ownerships, management strategies, and ecological conditions in the range of the spotted owl. Validation areas will initially be selected from LSRs, matrix, adaptive management areas, and other areas to represent the range of habitat conditions used by spotted owls.

Validation level descriptions—*Validation level 1*: Model validation at level 1 would require a 2-year survey to determine distribution and occupancy of owls in the selected areas, based on standard survey protocols (appendix A). The number and distribution of pairs observed would be compared with predicted values based on the habitat models. The degree of correspondence between predicted and observed occupancy for large areas (that is, 50 to 75 pair samples) is a measure of the extent to which the model is valid and reliable.

Validation level 2: Model validation at level 2 would require a 5-year survey to understand the demographic performance of owls in the new survey areas. These observed demographic parameters would be compared to those predicted by the habitat-based models. The degree of correspondence between the predicted and observed values for productivity, turnover rates, and occupancy rates necessary for model acceptance will be addressed during validation.

Predictive models likely will be tested and validated additionally during this phase to refine the existing models and develop "improved" ones for predicting the occupancy and distribution of owls in all ecological conditions, land ownerships, provinces, management strategies, and land allocations throughout the range of the owl.

Implementation

Based on the outcome of the validation process, models shown to be reliable predictors of owl occupancy will be used to track population trend under prediction level 1 (below). If models are shown to be reliable predictors of demographic performance under validation level 2 they will serve the additional monitoring function described in prediction level 2 (below).

Prediction level descriptions—*Prediction level 1*: Prediction level 1 will provide estimates of the occupancy and distribution of owls in various portions of the range of the owl. Predictions made in subsequent years, given changes in habitat, will provide estimates of population trend. Predictions of trends in occupancy and distribution will likely provide sufficient monitoring data for the Forest Plan, provided that mark-recapture techniques are continued. We propose that the subset of four demographic study areas, described in "Overview of Sampling Methods," above, continue as reference and comparison areas.

Prediction level 2: Prediction level 2 will provide predictions of demographic performance at the scale of the individual territory in addition to occupancy and distribution. The detailed information obtained in prediction level 2 may be necessary to more precisely assess the status and trends in spotted owl populations. This effort would provide more definitive information about demographic performance and annual rate of population change of owls than would prediction level 1.

Recommended Levels

The spotted owl effectiveness monitoring plan subgroup recommends the following levels of monitoring be implemented under the identified components of the plan.

- **Population monitoring**. Survey level 1 with companion habitat assessment for the demographic study areas.
- **Habitat monitoring**. Habitat level 2.
- **Predictive modeling**. Actively pursue development of models to predict occupancy and demographic performance of owls, and follow up with validation of the models.

Quality Assurance

Assurance of the quality of data collected and the methods used to summarize, analyze, and interpret the data will be applied to all three aspects of the effectiveness monitoring plan: population survey, habitat assessment, and predictive model development. For population surveys, survey timing in demographic study areas, determination of sex and age of individual owls, and capture and marking methods will be conducted according to the protocols provided in appendix A. Summarization and analyses of the data from the demographic study areas will be subject to the protocols in appendices B, C, and D. Survival and reproduction data along with estimates of population trend will be analyzed by using the procedures described in Forsman et al. (1996).

For landscape-scale habitat assessment we will rely on the quality assurance protocols for the production of the regionwide vegetation map. Quality assurance for the derived spotted owl habitat maps will rely on the knowledge of province-specific experts as they define the habitat attributes at both the demographic study area scale and province scale.

Validation of the predictive models is designed to test the accuracy of the models and evaluate their applicability to the various provincial settings outside the demographic study areas where they were developed. Comparison of observed and predicted outcomes also will allow an estimate of the uncertainty associated with model predictions. An uncertainty estimate is essential for decisionmakers to assess risks associated with their decisions and for scientists to assess the efficacy of the models.

Data Analysis and Reporting

Population Condition and Trend

Phase I—So that inferences about population trend from all demographic study areas are comparable, data for annual survival, reproduction, and owl turnover rate at sites in each area will be estimated by standardized protocols (appendices B, C, and D). Estimates of survival rates will be based on Jolly-Seber open-population models (for example, Program SURGE), as described by Franklin et al. (1996). Estimates of reproduction will be based on empirical counts of numbers of young produced by each female in the sample (see appendix A). These protocols were developed after years of experience and represent consensus among all prominent spotted owl field research leaders (Forsman et al. 1996).

Data about demographic trends in survival, reproduction, and annual rate of population change will be summarized annually for each demographic study area. A more comprehensive meta-analysis of all data sets (for example, Burnham et al. 1996) will be conducted every 3 years, starting no later than December 1998. Interpretation of results will continue to address uncertainties about the significance of adult emigration, possible biases in estimating fecundity, the effects of aging, and differential detectability of nesting and nonnesting pairs. These topics require further research and should be explored by the agencies. Reports will include an annual summary for each demographic study area and a more detailed report for the meta-analyses.

Phase II—Estimation of population status and trend will continue as in phase I, but in a subset of demographic study areas. Analytical methods and reporting schedules will be essentially unchanged from phase I. During phase II, reliance on trends in habitat condition and use of predictive models to assess trends in owl occupancy and demographic performance will increase. We anticipate being able to predict occupancy, distribution, and possibly demographic performance of owls, based on trends in habitat amount, condition, and distribution. For each area where the predictive model is applied for validation purposes, information about the location, size, and existing habitat conditions is necessary, as well as field-based estimates of the population parameters that were predicted.

Habitat Condition and Trend

Habitat condition and trend information will be estimated every 5 years after the baseline habitat map is developed. Monitoring over time will allow for estimates of change in amount and distribution of spotted owl habitat and for relating such changes to implementation of the Forest Plan.

Habitat trend reports will tabulate information about acres of habitat by land allocation and their percentage of change over time. In addition these data will allow tests of specific assumptions of the Forest Plan including the anticipated role of the network of reserves, in particular the LSRs. The Forest Plan assumes that reserve areas are resilient to significant natural alterations. Further, the Forest Plan assumes that northern spotted owl habitat, in areas not protected from human-caused alterations, will decline in amount and distribution no faster than predicted in the FSEIS (USDA and USDI 1994a). Based on these assumptions, a test could be developed to determine if changes in the amount and distribution of northern spotted owl habitat are at the rates anticipated in the FSEIS, both within and outside LSRs.

It also may be possible (and useful) to estimate habitat status and trend at the home range scale. Such measurements would be based on the use of extensive forest inventory plot data (Max et al. 1996). Here the appropriate habitat indicators would be attributes associated with large tree resources (standing live trees, snags, downed wood, and logs), and how their number and distribution are changing through time.

Monitoring Results

The accomplishments of effectiveness monitoring for spotted owls will be provided in annual summary reports (see Mulder et al., in press, for details of the reporting process for the effectiveness monitoring program). An interpretive report of effectiveness monitoring for spotted owls will be completed every 5 years beginning in December 1999. This report will evaluate the effectiveness of the Forest Plan in arresting and reversing the decline in spotted owl habitat and populations. We recommend that a panel of scientists prepare the interpretive report by evaluating the annual summary reports relative to the monitoring goals and objectives and the overall goal of maintaining the viability of owl populations. This report will provide decisionmakers with a scientifically credible evaluation of the state of spotted owl populations and habitat under the Forest Plan, and if necessary, make recommendations for changes in management practices. The report may not be able to fully address these issues with desired certainty until phase II is implemented.

Expected Values and Trends

The status and trend of owl habitat and projected population responses (as predicted by the models) will provide managers with feedback about existing conditions and allow comparison with future expected conditions. The results of these comparisons will provide information for review of the adequacy of management direction. If the trend, or rate of improvement, in habitat conditions is significantly below expectations, then a change in management practices may be required. These changes may involve land-use allocations or management standards and guidelines. We provide an initial list of expectations for owl habitat and populations:

1. It is expected that owl populations will continue to decline over the short term with the decline proceeding at a faster rate for owls in the matrix than in LSRs.

2. In the longer term, owl populations in LSRs are expected to be self-sustaining as individual LSRs reach a condition where at least 60 percent of the land area is comprised of owl habitat.

3. Habitat conditions within LSRs will improve over time at a rate controlled by successional processes in forest stands that currently lack the vegetation structure to be owl habitat.

4. Habitat conditions outside LSRs will generally decline due to timber harvest and other habitat-altering activities, but the vegetation structure across the landscape will continue to facilitate owl movements.

5. Catastrophic events are expected to halt or reverse the trend of habitat improvement in some reserves; however, the repetitive design of the LSRs should provide adequate resiliency in the overall reserve network so that catastrophic events do not result in the isolation of segments of the owl population.

During implementation of the monitoring plan, additional definition can be added to various expectations to provide detail and facilitate a quantitative assessment; for example, the expected rate of habitat change could be estimated and graphed. The results of habitat monitoring would be compared to the projection to determine if habitat change was within the expected range.

Additional tracking of demographic information will provide data about population parameters; for example, given data from past studies (Forsman et al. 1996), expected values for adult survival range from 0.82 to 0.87. Monitoring adult survival and noting whether the values are in or out of the expected range will provide insight for judging the success of the management strategy beyond just a single, cumulative indicator, such as the rate of population change.

We do not expect that a change in management direction would be based on any one value or expectation or that a change would be triggered solely because one or more of the measured parameters is outside the range of expected values. We expect, moreover, a review and decision process that looks carefully at the elements we have listed above, both individually and in combination. There will be no sirens or alarms wired to these elements to sound a signal for change. We will be responsible for interpreting the monitoring results, and if needed, signaling ourselves of the need for change. In the end, this monitoring strategy will provide data only about owl habitat and populations. Knowing how much habitat there is, the survival rates of owls, and how many young they produce are important indicators, but we will be required to assess the indicators and decide whether the plan is proceeding as planned and yielding the results we expected.

Table 3—Permanent full-time equivalent (FTE) personnel needed for the northern spotted owl effectiveness monitoring plan, estimated by general monitoring task

	Permanent FTE requirements by fiscal year									
	Phase I							Phase II		
Monitoring task	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Demographic study area survey and habitat assessment	NA	NA	10	10	10	10	10	4	4	4
Rangewide habitat assessment	NA	NA	3	4	3	2	2	2	2	2
Predictive model development and implementation	NA	NA	2	3	3	2	2	1	1	1
Predictive model validation	NA	NA	0	0	0	2	2	0	0	0
Total annual FTE need	NA	NA	15	17	16	16	16	7	7	7

NA = not applicable.

Table 4—Summary of the annual funding estimate for the northern spotted owl effectiveness monitoring plan, by general monitoring task

	Funding needs by fiscal year									
	Phase I							Phase II		
Monitoring task	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
	Thousand dollars									
Demographic study area survey and habitat assessment	1840	1690	1870	2050	2050	2150	2150	1100	1100	1200
Rangewide habitat assessment	0	0	50	200	120	40	45	45	48	48
Predictive model development and implementation	50	194	320	335	350	300	160	120	80	80
Predictive model validation	0	0	0	0	0	800	800	0	0	0
Total annual funding	1890	1884	2240	2585	2520	3290	3155	1265	1228	1328

Organizational Infrastructure

The monitoring program outlined in this document will require a coordinated interagency effort. The four Federal agencies with primary responsibility for implementing the plan are the Forest Service, BLM, National Park Service, and U.S. Fish and Wildlife Service (USFWS). Cooperation and assistance in the form of technical support and funding are expected from the Biological Resources Division of the U.S. Geological Survey.

The key to successfully implementing the regionwide monitoring program is a coordinated network of agency personnel and cooperators who will implement individual elements of the monitoring strategy. The annual population surveys, periodic habitat assessments, cumulative data analyses, and integrated syntheses of the individual monitoring efforts (province scale) will implement the monitoring strategy as a whole. Steps to accomplish the strategy are assigning specific tasks to an administrative unit, gathering and analyzing the data through standardized methods (some of which await development), and implementing the monitoring program on schedule.

We recommend that each of the primary Federal agencies assign a spotted owl monitoring lead, an individual who will work with interagency counterparts as the Spotted Owl Effectiveness Monitoring Implementation Group. This body would work with agency personnel and cooperators enlisted to conduct the demographic studies, assess habitat conditions, and develop predictive models. It also would coordinate the participation of Federal land managers and key resource management personnel to assure adequate funding and that survey results are integrated into the annual summary reports. The group also should establish contacts with other scientists outside the Federal community who are conducting spotted owl monitoring and research.

The Spotted Owl Effectiveness Monitoring Implementation Group will require agency support, with an estimated equivalent of two permanent, full-time positions among the five participating agencies. In addition to agency support of coordination activities, support will be needed for permanent, full-time agency personnel engaged in implementing the plan. Personnel estimates are summarized in table 3. Assuming that the demographic studies are continued under the current cooperative working relations and model development is done in-house, these full-time equivalent requirements would involve research scientists, research wildlife biologists, statisticians, and GIS specialists from the research and management branches of the agencies. Time commitment of individuals is expected to range from 15 to 80 percent, depending on the task and the fiscal year.

Summary of Estimated Costs

A summary of the estimated annual funding needed for implementation of the effectiveness monitoring strategy is in table 4. Funding estimates are provided for each general task category through 2005. All estimates account for a 25-percent administrative charge and an inflation rate of 5 percent applied every 2 years beginning in 1997.

The population monitoring and companion habitat classification in the demographic study areas constitute the major portion of the funding in the initial years. Costs are estimated to range from $1.9 to 2.1 million from 1998 through 2001. It should be noted that this level of funding will require only a modest increase from current levels as evidenced by the expenditures for 1996 and 1997.

Table 5—Implementation schedule for the northern spotted owl effectiveness monitoring plan

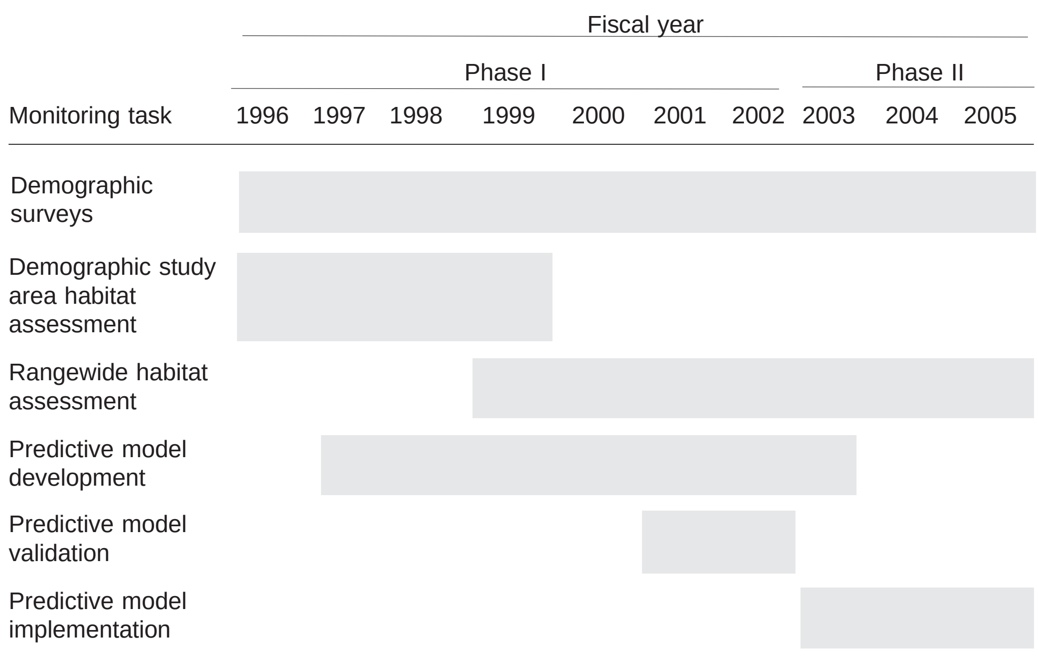

Table 6—Implementation tasks for the northern spotted owl effectiveness monitoring plan

		Fiscal Year		
Approach	Task	1998	1999	2000
Population	Assign demography study coordinator	X	X	X
	Demography area population and habitat work	X	X	X
	Conduct meta-analysis	X		
Habitat	Define attributes by province	X		
	Assign habitat study coordinator	X	X	X
	Produce rangewide habitat map		X	
	Maintain rangewide habitat map			X
Model development	Assign model development coordinator	X	X	X
	Model development	X	X	X
Annual summary report	Complete report	X	X	X
Interpretive report	Complete report			X

Development of the rangewide spotted owl habitat and dispersal habitat map is estimated to cost $200,000. Expenditures in future years will average $45,000 for annual map maintenance and an additional $150,000 to recompile the map at year ten. These costs will be in addition to the cost estimates for the maps described in the late-successional and old-growth forest effectiveness monitoring plan (Hemstrom et al. 1998).

Development of the predictive models for the respective demographic study areas will occur during a 3-year period beginning in 1998 and cost about $330,000 per year. Following development, 1 to 2 years of testing and validation will be conducted outside the areas where the models were developed. It is estimated that the costs for validation will be $800,000 annually for 2 years.

If the predictive models meet the needs of the decisionmakers and the expectations of the scientists, phase II of the plan will shift the workload to surveys of the set of four reference demographic study areas at a cost of $1.1 million annually. Additional annual costs in phase II would be $50,000 for habitat map maintenance and $80,000 for maintenance and application of the predictive models.

If the decision is to implement survey level 2, the cost for population monitoring is expected to be $2.5 to 3 million annually, and for level 3 it would range from $3 to 5 million annually. Costs for habitat-related monitoring would increase by moving to habitat level 3, but due to the uncertainty of the level of field sampling needed, it was not possible to estimate the cost.

Implementation Schedule

The implementation schedule for the northern spotted owl effectiveness monitoring plan is summarized in table 5; refer to table 4 for comparison of the summary of tasks and associated costs by year. Specific tasks and associated resources for implementation through the first 3 years of the monitoring program are presented in table 6. Interpretive reports would be generated every 5 years, beginning with the initial report at the end of 1999, and will include the results of the 1998 meta-analysis of demographic data; project or summary reports would be provided annually. Reporting on the habitat component is largely dependent on the schedule for LSOG monitoring (Hemstrom et al. 1998).

Research Needs

The following list identifies research topics considered key to implementing the spotted owl effectiveness monitoring plan (no priority order to the list):

- Understanding relations among habitat structure, prey ecology, home range of individual owls, and variation in the vital rates of the owl population.
- Owl habitat characteristics and the implications of using vegetation attributes for habitat classification.
- Role of the amount, type, and pattern of habitat and the implications on speed, pattern, and survival of dispersing juvenile spotted owls.
- Use of remotely sensed vegetation information as a tool for identifying and mapping spotted owl habitat.
- Assessment of a random census plot technique for estimating spotted owl population trends.

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Appendix A: Standardized Protocols for Gathering Data on Occupancy and Reproduction in Spotted Owl Demographic Studies[1]

This protocol provides both general and specific direction for implementing demographic field surveys for the northern spotted owl monitoring plan. All areas will be surveyed according the methods described herein. Any deviations from these methods must be approved through the spotted owl monitoring coordinator. This protocol is available from Forsman (see footnote 1).

Survey Period

In general, surveys to establish the presence of territorial pairs, confirm bands of previously marked owls, and establish reproductive status will take place between 1 March and 1 September. A later starting date may be appropriate in some areas (for example, higher elevations in the Cascades Range), where pairs may not begin to roost together until late March.

Survey Methods

The intent of the survey is to obtain complete coverage of the area of interest such that owls will be able to hear the surveyor and the surveyor will be able to hear the owls.

Calling stations and survey routes must be established to achieve complete coverage of the area. Calling stations should be spaced 0.25 to 0.5 mile apart, depending on topography. Take advantage of prominent points within the calling area when establishing calling stations.

Whether owls are located or not, the following information should be recorded on a standard site visit form for each visit to a given site: (1) brief description of survey route, (2) survey start and stop time and total time of survey, (3) weather (including estimated wind speed and precipitation), and (4) survey results. Note species and number of all owl responses, regardless of species, including sex and age (if known), time of response and whether it was an audio, visual, or both. For multiple or moving owls, record and number each response or observation.

- For each visit, whether positive or negative results, map (preferably on a U.S. Geological Survey topographic map, orthophoto, BLM, or Forest Service transportation map or some other high-quality map), the following:

1. Route surveyed and stations called.

2. All spotted, barred (*Strix varia*), great horned (*Bubo virginianus*), saw-whet (*Aegolius acadicus*), pygmy (*Glaucidium gnoma*), screech owl (*Otus kennicottii*), and accipiter response or observation locations. For multiple or moving owls, map all response or observation locations and number each location to correspond with survey results.

Characterize any behavioral observations. Make note of types of vocalizations heard, movements of owls (toward or away from you), or situations such as one response is received and the owl is quiet thereafter. This will give the person(s) analyzing the data and determining activity centers additional information to consider.

[1] Protocols prepared and periodically updated by Eric Forsman, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; revised March 29, 1995.

Be especially cognizant of the possibility that you may hear hybrid owls, and make careful notes of unusual vocalizations.

- Conduct night surveys between sunset and sunrise. Be sure not to call the same section of a survey route at the same time on each survey effort (that is, change the start time and the end of the route).
- Do not survey under inclement weather conditions, such as high winds (> 10 miles per hour) rain, or high noise levels (stream noise, machinery, etc.), which could prevent hearing a response that would be heard under better conditions.
- Systematically survey the area of interest until an owl responds, or if no response, until a minimum of three complete night visits are conducted each year. Survey effort should be spread out over 2 to 3 months to avoid survey efforts concentrated in a short timespan (for example, in a 3-week period at the first of the survey season).
- Where survey seasons are restricted (because of snow, landslides, mud, bridge failures, etc.), the survey period may be adjusted to fit the conditions.
- Surveys may be conducted during the day where there are no roads or foot trails to traverse at night, or there are safety concerns.
- Owl calls may be imitated with taped recordings, vocal mimics, reed callers, or any other method producing a good facsimile of spotted owl vocalizations.
- Follow the survey methods listed below (spot calling is the recommended method). Whatever method used, be certain to cover all potential areas within the transect area.

1. Spot calling. Set up a series of calling points about 0.25 mile apart along a road. When possible, select prominent points that cover large areas. Spend at least 10 minutes at each point, more if the topography prevents you from hearing birds that might respond from the previous calling point (for example across a major ridge). If the topography lends itself to fewer prominent calling points, spend more time at each point.

2. Continuous walking or leapfrog surveys. Walk the designated route, stopping at frequent intervals to call and listen for responses. If two people are involved, use a leapfrog method (see Forsman 1983).

- If spotted owls are heard during a survey:

Estimate the original and final location of the owl(s). The best method is to triangulate on the owl's calls, taking compass bearings from two or three locations. Be certain to record on the survey form the method used to estimate the location.

Record the location on a map or photo attached to the survey form.

The triangulation and accompanying map provide a way to verify the location.

- If an owl responds at any point, record the data as required. If no response is heard, proceed to the next calling point. Continue until the defined survey area is completely covered.
- If a response occurs during daylight hours and you have sufficient time to complete a status verification, do so.

- If an owl responds at night, return to the area during the day as soon as possible (followup visit) to verify status as described below.
- When a bird responds at night, complete the survey route for the remaining points that are beyond earshot of the responding bird. Beyond earshot is generally over a ridge or at least 0.5 to 0.75 mile away. Completing the route will provide an opportunity to detect any other owls in the area.

Occupancy Status

Determination of nonoccupancy—A minimum of three visits are required to establish nonoccupancy of an area. At historical sites this normally will involve an initial daytime visit to the historical core area, followed by at least two nighttime surveys of the area extending 1 to 2 miles out from the core, depending on the location of adjacent pairs. In areas without previous records of occupancy, the three visits normally would be nighttime surveys of the entire area. Additional visits are permissible, but three is the minimum.

Determination of occupancy—A site will be considered occupied by a pair if any of the following occurs:

1. Two marked individuals that have been paired in previous years are found alive on one or more occasions between 1 March and 30 September anywhere within a 1-mile radius of the traditional site center. There is no requirement that they be seen near each other, so long as they appear to be occupying the historical site. In cases where both pair members are confirmed alive within the historical range, but where one or both members are occasionally found roosting with other birds (not unusual in non-nesting years), we will usually classify the two historical pair members as a "pair."

2. In cases where birds are unmarked or their bands are not seen, birds will be classified as a pair if a male and female are heard or observed within a 0.5 mile of each other on one or more day visits or on two or more night visits. Male and female locations do not need to occur on the same visit. For example, pair status would be assumed if a male and female were heard one night, a female was heard another night, and a male on another night. Note that this involves changes from the old protocol, which specified that locations of pair members be on same day and no more than 0.5 mile apart. Note also that both birds must either be heard giving calls that are definitely identifiable as spotted owl calls or be seen and positively identified as spotted owls. This is to avoid the possibility that a mixed species pair will be recorded as a spotted owl pair.

3. A male spotted owl takes a mouse to a female. To be called a spotted owl pair, the female must be either (1) positively identified by visual observation or (2) heard giving definite spotted owl calls. Otherwise, the site should be listed as occupied by a pair of undetermined composition.

4. A female is detected on a nest. If both she and the male are not (1) positively identified by visual observation or (2) heard giving definite spotted owl calls, then it should be called a pair of undetermined composition.

5. One or both adults are seen with young. To be called a spotted owl pair, both adults must be positively identified by visual observation, or the young must be seen late enough in the season to examine their plumage to ensure they are not hybrids.

6. If juveniles in advanced stages of plumage development are observed and they are identified as spotted owls (a trained observer can identify hybrids once the feathers on the breast and abdomen develop in late July and August).

Because of the potential for hybridization, it is becoming increasingly important to confirm the identity of both pair members. In the case of females heard on the nest, be aware that the contact calls of female barred owls and spotted owls are essentially identical. Thus, if there is any suspicion that barred owls are in the area, you should definitely return to the site to confirm the species of the female.

Resident single status—Resident single status will be assigned to any location with the presence or response of a single owl within the same general area on three or more occasions during a single breeding season or two successive seasons, with no response by an owl of the opposite sex after at least three complete surveys. Responses over two seasons should occur in the same general area. Determining if responses occur within the same general area should consider topography and the locations of adjacent owl activity areas.

If a single bird is detected, at least two additional visits should be conducted to determine if a pair is present. These visits all should take place during the breeding season in which the first response is heard.

Nesting Status

Nesting status surveys may be conducted from 1 April to 31 May in Oregon and 1 April to 15 June in Washington and at high elevations in Oregon. If females are detected on the nest before these dates, those earlier visits may be counted as well. If nesting has not been confirmed earlier, at least one visit should be made during late April or May, when females definitely should be incubating or brooding. Species of the male and female must be clearly established to avoid any possibility of confusing hybrids and spotted owls.

To avoid missing a late nesting attempt it is important that visits not all take place in early April. If early visits do not provide evidence of nesting, at least one visit should take place after 15 April in Oregon and 1 May in Washington and at higher elevations in Oregon.

Mice—The primary technique used to assess nesting status will be to feed live mice to owls and then observe the owls to see what they do with the mice. Protocol for this procedure is as follows:

Locate one or both members of pair during the day and offer them at least four mice. Describe what the owls do with each mouse (eat, ignore, cache, carry to nest, etc.). If only a single bird is located, the same protocol is followed. If you are unsure whether a mouse was eaten or cached, but are sure that it was not carried to a nest or to young, be sure to so indicate. In other words, do not simply record that you have no idea what happened to a mouse when you are sure that it was not taken to a nest or to young birds.

If the owl(s) caches the mice or simply roosts with a mouse for prolonged periods, then “mousing” can end after three mice are given to the adults.

If an owl takes a mouse and flies away, follow it as closely as possible to determine where it takes the mouse. If you are unable to follow the owl, and do not know if the mouse was taken to a nest or to fledged young, then that mouse should not be counted toward the requirements of protocol. Be ready to pursue, as owls sometimes carry mice several hundred yards to reach their nests or young.

Do not feed any more mice than necessary to determine nest location and nest status. We are not in the business of habituating owls to humans.

Positive confirmation of nesting—Owls will be classified as nesting if any of the following are observed:

1. A female is detected on a nest or either a male or female carries prey into a nest on two or more occasions within the dates specified above. After 15 April in Oregon and 1 May in Washington, nesting may be confirmed on the basis of only one occasion where a female is observed on a nest or when a male or female carries prey into a nest. The two-visit protocol for confirmation of nesting is dropped after the specified dates, because there is little chance owls will continue to sit in the nest without actually laying eggs after the first 2 to 3 weeks of the nesting period.

2. A female possesses a well-developed brood patch when examined in hand during April, May, and June. Presence of a small bare area or molting feathers on the abdomen should not be counted as a brood patch. This is somewhat of a judgment call. When in doubt, use other criteria such as results of mousing or observations of roosting. Describe the brood patch, including dimensions and visual appearance of skin.

3. Young birds are observed in the presence of at least one adult. Because of the possibility of hybridization, an effort should be made to confirm the species of both parents. This is not necessary if the species of juveniles can be conclusively determined. Always examine juveniles carefully to make sure that they are not juvenile barred owls or hybrids.

4. Eggs, eggshells, or remains of nestlings are found in or under a nest.

Confirmation of nonnesting status—Confirmation must take place before June 1 in Oregon and 15 June in Washington. The 15 June cutoff also may be used at higher elevations in Oregon if biologically appropriate. With these cutoffs, some pairs inevitably will be classified as nonnesting when they in fact nested and failed. This means that estimates of the proportion of the population that nests may be somewhat underestimated because the estimate will include some pairs that nested and failed early in the season.

To classify a pair or a female as nonnesting, the four-mouse protocol should be conducted on one or both members of the pair on at least two occasions with no evidence of nesting. To be considered a valid attempt, at least two mice must be taken.

If visits to document nesting are made in April they should be at least 3 weeks apart so that late nesting attempts will not be overlooked. Visits to determine nesting status in May or early June may be done at any interval, including consecutive days. One-day intervals between nesting visits are permissible later in the season, because there is little chance that a late nesting attempt will be overlooked during that period.

Pairs or single females that are not checked at least twice before 1 June in Oregon and 15 June in Washington should be listed as "**nesting status undetermined**." Exceptions to this two-visit protocol are:

1. Female does not possess a brood patch when examined in hand between 15 April and 15 June (if this occurs, nonnesting status can be confirmed based on one visit).

2. Females believed to be nonnesting based on one visit between 15 April and 1 June, and which then cannot be located despite repeated return visits to the area. Cases like this are not uncommon in poor nesting years, when pairs briefly return to their traditional nest areas, then split up and become difficult to locate.

3. Females observed roosting for 30 minutes or more between 15 April and 15 May, showing no sign of attachment to a nest or young, may be classified as "nonnesting" based on a single visit. Females normally should be incubating eggs or brooding young during this period. This technique should not be used for confirmation of nesting after 15 May, as it is common for females with well-developed nestlings to remain out of the nest for prolonged periods. When possible, do a second non-nesting confirmation visit to make sure.

Confirmation of nest failure—A nesting attempt may be classified as "failed" if:

1. A pair is initially classified as nesting, but on two or more subsequent visits, one or both pair members eat or cache all mice offered (four-mouse protocol). At least two mice must be taken to qualify as a test. The two visits to confirm failure can take place anytime after nesting is first confirmed. At least one of the follow up visits to confirm failure must occur before 1 June in Oregon and 15 June in Washington. The second visit can occur anytime before 31 August. (**Previous protocol specified that both visits had to occur by 1 June**.)

2. A pair is initially classified as nesting, but neither bird can be relocated on two or more visits to the nest area after the initial confirmation of nesting. At least one of the followup visits to confirm failure must take place before 1 June in Oregon and 15 June in Washington. The second visit can occur anytime before 31 August. (**The old protocol did not include this option**.)

3. A combination of 1 and 2 above (for example, one visit where owls eat or cache all mice, and another where they cannot be located).

Number of Young Produced

This measure of reproduction is the most important measure we take, because it is the basis for estimates of fecundity. The number of young produced is averaged for **all** females, whether they are paired or not. Because fecundity is normally subdivided by age class (subadult 1, subadult 2, adult), it is critical that age of each male and female be determined, even if that requires repeated visits to document. If bird is first banded as a subadult, its age should be estimated from feather wear.

The measure of reproduction is the number of young that leave the nest. It is not permissible to count "branchers" (young birds sitting on branches in the nest tree) unless you are certain that there are no other young hidden in the nest. The concern with counts of branchers is that young hidden in a nest not be overlooked.

Pairs or single females—Pairs or single females will be classified as producing no young if:

1. They are confirmed to be nonnesting based on protocols for determination of nesting status (refer to criteria above).

2. They are provided mice[2] to protocol on two or more occasions before 31 August, with no sign of young. This may include any combination of reproductive status visits and fecundity visits. For example, if a single visit in late May suggests no young produced (for example, adults eat or cache all mice), this could be combined with a single visit later in the summer that also indicates no young produced.

3. Female is observed and designated as nonnesting on one or more occasions in April-May (April to 15 June in Washington), but neither she nor her mate can be relocated later in the summer, despite repeated attempts (minimum of two) to relocate them. As a result, they cannot be moused to determine number of young produced. This change in the protocol is needed to address the behavior of some nonnesting birds or birds that nest and fail; they sometimes become difficult to locate and cannot be confirmed as having produced no young.

For pairs that produce young, brood counts may take place anytime after the young fledge until 31 August. However, a determined effort should be made to count the number of young produced as early as possible after broods fledge, preferably before 30 June in Oregon and 15 July in Washington. The objective is to document the number of young produced before any mortality occurs.

After the first occasion when young are counted, at least one followup visit should be made to ensure that all young were observed on the first visit. If owlets are found under a known or suspected nest tree in late May or June, then the followup visit to confirm the number of young fledged should take place at least 3 days later to make sure that all young have time to leave the nest. In all other situations, the 3-day interval between the first and second visit is not required (that is, visits can be as close as 1 day apart).

To estimate the number of young produced, offer four mice to one or both adults on both visits and count the maximum number of owlets seen or heard. A visit counts for determination of number of young produced, as long as an adult takes at least one of the four mice offered.

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[2] Protocols for spotted owls commonly use the phrases "to mouse" or "to be moused" when providing mice to determine their reproductive status.

Appendix B: Standardized Protocols for Estimating Reproduction Rates at Sites Historically Occupied by Spotted Owls[1]

This is an analytical protocol for combining reproductive data sets and does not apply to or amend protocols for conducting occupancy and reproduction surveys in demographic studies. For each criteria, the least restrictive definition that could be agreed on was used. The database file structure supporting this protocol is available from Forsman (see footnote 1).

Quantifying Site-Specific Reproduction

The index is to be calculated for only those sites occupied by a pair in at least one year during the study period. Pair status will be defined by using the definition found in appendix A. Include values for all years of the study (including years prior to first pair status confirmation) for each site included.

1. A nine (9) will be entered when the following "unknown" status conditions occur:

a. Less than three visits were attempted and no reproductive determination could be made. Followups do not constitute additional visits.

b. When a pair is detected and protocol was not followed or met when attempts were made to ascertain the number of young produced (see item 5, (b) below, for exceptions to this rule).

c. During the period when owls carry a backpack styled transmitter. They may be included, however, after removal of the transmitter. (Note: Owls fitted with tail-mounted transmitters can be included in calculations for the entire time that the devices are attached.)

d. Data are not available to make a reproductive determination.

2. An eight (8) will be entered for sites surveyed for occupancy status at least three times (1 March to 31 August) and the site was "unoccupied" because:

a. No owls responded.

b. A pair or resident single could not be confirmed.

3. A seven (7) will be entered for years when sites meet "resident single" status. Resident single status is established by the response of a single owl on two or more visits within the season, with no response by an owl of the opposite sex after three complete visits. In cases where a "known-sex" owl responds and subsequent "unknown-sex" responses occur, attribute all responses to the known-sex bird. A single response or observation of a banded owl will serve to meet resident single status in cases where the three-visit minimum is met and the observed owl was previously confirmed on the site.

4. A six (6) will be entered in cases where "resident single" status is met for one owl **and** where there was also a response(s) from an opposite sex individual but pair status could not be confirmed.

[1] Protocols prepared and periodically updated by Eric Forsman, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; revised January 1, 1995.

5. A zero (0) will be entered for “pairs” that do not produce young if:

a. Owls were moused in the area by using the mousing protocol and a nonnesting or no-young-produced determination, or both, was made.

b. Sites meet pair status, but do not meet protocol standards for reproductive determination, and at least two visits were made to relocate and offer mice to the owl(s) after the initial detection.

6. Numeric values (for example, 1, 2, or 3) will be entered when young are produced and observed at the site.

a. The maximum number of live young counted at any time during the season will be entered in the matrix.

b. Fledglings must leave the nest tree alive to be counted.

c. Young found dead are not counted. But, if fledglings are known to have been killed after being previously located (out of the nest tree) alive, then they are counted.

Appendix C: Standardized Protocols for Estimating Occupancy Rates at Sites Historically Occupied by Spotted Owls[1]

Quantifying Site-Specific Occupancy

The codes, listed below, have been developed for combining data sets and do not apply to or amend individual study area protocols for conducting demographic studies. Definitions of "pair," "resident single," and minimum survey effort required for inclusion of data will be the same as outlined in the protocol for site-specific reproduction (see appendix B). The database file structure supporting this protocol is available from Forsman (see footnote 1).

The index is to be calculated for sites with pairs or resident singles for at least 1 year in the history of the site. Additionally, birds carrying backpack-style transmitters may be included in this index. **(Note: This includes more sites than the analysis of site-specific reproduction, and birds carrying backpack styled transmitters were excluded from that analysis.)** Additionally, it might be wise to include data on sites surveyed to protocol (three visits or more) but never occupied during the course of your study (if you have those data).

The codes are as follows:

1 = A pair or two resident singles of opposite sex

2 = Resident single male

3 = Resident single female

4 = Resident single of unknown sex

5 = Resident single male with female response

6 = Resident single female with male response

7 = Male and female detected, pair status unknown, and neither individual meets "resident single" status

8 = Detection of male, female, or unknown sex not meeting resident single status (floaters)

9 = Unoccupied

0 = No data or insufficient survey

Make a judgment call for those cases where the same bird or birds occupy more than one site in a given year. This is such a rare event that it is probably irrelevant.

[1] Protocols prepared and periodically updated by Eric Forsman, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; revised March 25, 1996.

Appendix D: Standardized Protocols for Estimating Turnover Rates at Sites Historically Occupied by Spotted Owls[1]

Quantifying Site-Specific Turnover

The codes, shown below, have been developed to track site-specific turnover of individual owls. This parameter will be tracked with separate fields for male and female owls. The database file structure supporting this protocol is available from Forsman (see footnote 1).

1 = The presence of the previously marked owl is confirmed by direct observation.

2 = Replacement by another owl at the site with no observation of the previously marked owl (see note (E), below).

3 = Reobservation of the marked owl at a different site (that is, the marked owl is known to have moved away from the original site for at least 1 year).

4 = Recovery of the carcass of the owl or other confirmation of death.

5 = Failure to verify the presence of the marked owl for a period of 2 or more years using the standards for status surveys (three or more visits). Note: The site does **not** need to be vacant (see note (B), below).

6[2] = This number is used for the first year when a bird cannot be positively identified. If the bird is not identified in a subsequent year, then this code is changed to code 5. In cases where this code is followed by codes 2, 3, 4, or one or more 7's, then the code should be an x.

7 = Any cases where a determination of the events occurring between the two years could not be made are classified as undetermined (that is, use this code for all cases not meeting any of the other codes).

9 = Nines will be entered in year fields before the initial banding or initial identification of a banded bird of that sex at that site.

The following guidance should be used in assigning the codes listed above.

A. Anytime a bird is relocated after a period (of any length) of years when its presence at the site could not be verified, then the bird will be assumed to have been present in all interim years; code 1 will be filled in retrospectively for those years. This may underestimate instances where birds move from the site for one or more years and then return.

B. For birds "missing" for two sequential years record the turnover (code 5) for the first year the bird was "missing."

"Missing" means that the site was surveyed (three-visit minimum) and either (1) no bird of that sex was detected, or (2) a bird of that sex was detected but not identified.

Occasions will arise when we search a site for a particular bird for two years and detect a bird of that sex at the site in one or both years but fail to identify it. In cases where the detected bird really is the same bird as previously marked, this methodol-

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[1]Protocols prepared and periodically updated by Eric Forsman, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; revised March 25, 1996.

[2] By using this code we can (1) better document the year in which events actually occur, and (2) reserve the option to calculate annual turnover rates for study areas (if we ever wish to do so in the future) because we can later decide which year-interval to assign these turnover events to.

ogy will cause us to incorrectly classify it as a code 5 turnover. This problem is rare in occurrence and will be partially corrected for by note (A), above. This makes tabulation of turnover much easier and more straightforward (for example, any time a site is surveyed for two subsequent years after initially identifying a marked owl and no owl can be positively identified for both years, the site gets a code 5).

C. For occasions when a bird is found dead and is replaced by another bird in the same year, record the event as a mortality and not a replacement (that is, code 4 supersedes code 2).

D. For occasions when a bird is known to have moved and is replaced by another bird in the same year, record the event as a movement and not a replacement (that is, code 3 supersedes code 2). Also see (L), below, for additional information.

E. A two (2) should only be used when a replacement event is used to document the turnover of the previous bird. Do not use code 2 when a new bird occupies a site known to have been vacated by the previous bird (that is, the previous bird moved, died or disappeared, (3, 4, or 5, respectively).

F. For instances when a bird is identified in a given year and is then known to have been replaced (2), moved (3), or died (4) within the same year, treat the event as though it happened at the end of that season; for example, a male is banded in 1987 and then found dead on a subsequent visit during the 1987 season. Record the mortality in the record.

G. When a bird moves and then returns (with no replacement in the interim), the first year it returns should be coded with a seven (7) and not a one (1).

H. For analysis, fields with codes = 1, 2, 3, 4, 5 will be tallied as “owl-years” (codes 7 and 9 are nondata codes).

I. For analysis, fields with codes = 2, 3, 4, 5 will be considered “turnovers.”

J. For birds wearing a backpack-style transmitter, add a value of ten (10) to the code.

K. For birds wearing a tail-mount transmitter, add a value of twenty (20) to the code.[3]

L. In cases where a banded owl is missing (not confirmed) for two or more years and then is reobserved at a new site, the following rules apply:

(i) If there has been no replacement and a turnover has already been coded with a five (5) in the first year that the owl was not confirmed, then change the five (5) back to a six (6) and code the turnover as a movement by placing a three (3) in the column for the year that the owl was reobserved.

(ii) If there was a replacement before the original owl was relocated at the new site, code the turnover as a movement by placing a three (3) in the column for the year that the replacement owl was first observed.

These rules are in keeping with (D), above (code 3 supersedes code 2) and also help to code the movement or turnover as accurately as possible with respect to the year when it occurred.

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[3]Turnover supplement prepared and periodically updated by Eric Forsman, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, 3200 Jefferson Way, Corvallis, OR 97331; revised February 13, 1996.

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Lint, Joseph; Noon, Barry; Anthony, Robert; Forsman, Eric; Raphael, Martin; Collopy, Michael; Starkey, Edward. 1999. Northern spotted owl effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-440. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 43 p.

This report describes options for effectiveness monitoring of long-term status and trends of the northern spotted owl to evaluate the success of the Northwest Forest Plan in arresting downward population trends, and in maintaining and restoring the habitat conditions necessary to support viable owl populations on Federal lands. It describes options to address monitoring questions, profiles population and habitat status, and points out areas of progress and concern. How population and habitat data from demographic studies would be integrated in the development of predictive models is described. A process to report status and trend results is presented that would provide a reference document for decisionmakers during periodic land use plan reviews.

Keywords: Northwest Forest Plan, effectiveness monitoring, northern spotted owl, suitable habitat, demographic study, remote sensing, GIS, landscape, stand scale, predictive model.

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