NORTHWEST FOREST PLAN

THE FIRST 10 YEARS (1994–2003)

Status and Trends of Northern Spotted Owl Populations and Habitat

General Technical Report
PNW-GTR-648
September 2005

United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

The **Forest Service** of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the national forests and national grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA's TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write USDA, Director, Office of Civil Rights, Room 1400 Independence Avenue, SW, Washington, DC 20250-9410 or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Technical Coordinator

Joseph Lint is a wildlife biologist, U.S. Department of the Interior, Bureau of Land Management, Oregon State Office, 777 Garden Valley Blvd., NW, Roseburg, OR 97470. He is the module leader for northern spotted owl effectiveness monitoring under the Northwest Forest Plan.

Cover photograph by Tom Iraci.

Northwest Forest Plan—the First 10 Years (1994–2003): Status and Trends of Northern Spotted Owl Populations and Habitat

Joseph Lint
Technical Coordinator

U.S. Department of Agriculture, Forest Service
Pacific Northwest Research Station
Portland, Oregon
General Technical Report PNW-GTR-648
September 2005

Abstract

Lint, Joseph, tech. coord. 2005. Northwest Forest Plan—the first 10 years (1994–2003): status and trends of northern spotted owl populations and habitat. Gen. Tech. Rep. PNW-GTR-648. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 176 p.

This report presents results from monitoring spotted owl (*Strix occidentalis caurina*) populations and habitat during the first 10 years of implementation of the Northwest Forest Plan (the Plan). Estimated population decline ranged from 0 to 10 percent across study areas (weighted average of 3.4 percent) annually. The average annual rate of decline for the four demographic areas in Washington was 7.1 percent. Presence of barred owls (*Strix varia*), weather, past and present harvest of habitat, and wildfire and insect infestations that alter habitat are all possible contributors to the noted decline.

Maps depicting the suitability of habitat-capable area were produced by using habitat models. Rangewide (range of the owl), about 74 percent of the federal land area was habitat-capable. Fifty-seven percent of the habitat-capable area was in a forest condition similar to the conditions where territorial owls were known to be present on the landscape. Fifty-one percent of the habitat-capable area fell in large, reserved blocks intended, under the Plan, to support clusters of reproducing owls. About 62 percent of the habitat-capable area inside the reserved blocks was in a forest condition similar to the conditions where owls were known to be present.

Owl movement was assessed in selected provinces by using data from banded owls. Movements with resighting locations inside reserved blocks accounted for 51 percent of juvenile movement records. Over 30 percent of the juvenile movements were into reserved blocks from outside points.

Predictive model development using demographic data showed a variety of factors that influence owl survival and productivity including precipitation, owl age, and habitat.

The barred owl has expanded its range in past decades and currently is present throughout the range of the spotted owl. The likelihood of competitive interaction between spotted owls and barred owls raises concern on the future of spotted owl populations. Barred owls are high on the list of factors that may be contributing to spotted owl declines in northern portions of the spotted owl's range.

Barred owls, West Nile virus (*Flavivirus* sp.), and management of owl habitat in high-fire-risk areas are topics for future management consideration.

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

Preface

This report is one of a set of reports produced on this 10-year anniversary of the Northwest Forest Plan (the Plan). The collection of reports attempts to answer questions about the effectiveness of the Plan based on new monitoring and research results. The set includes a series of status and trends reports, a synthesis of all regional monitoring and research results, a report on interagency information management, and a summary report.

The status and trends reports focus on establishing baselines of information from 1994, when the Plan was approved, and reporting change over the 10-year period. The status and trends series includes reports on late-successional and old-growth forests, northern spotted owl (*Strix occidentalis caurina*) population and habitat, marbled murrelet (*Brachyrampus marmoratus*) population and habitat, watershed condition, government-to-government tribal relationships, socioeconomic conditions, and monitoring of project implementation under Plan standards and guidelines.

The synthesis report addresses questions about the effectiveness of the Plan by using the status and trends results and new research. It focuses on the validity of the Plan assumptions, differences between expectations and what actually happened, the certainty of the findings, and, finally, considerations for the future. The synthesis report is organized in two parts: Part I—introduction, context, synthesis and summary—and Part II—socioeconomic implications, older forests, species conservation, the aquatic conservation strategy, and adaptive management and monitoring.

The report on interagency information management identifies issues and recommends solutions for resolving data and mapping problems encountered during the preparation of the set of monitoring reports. Information management issues inevitably surface during analyses that require data from multiple agencies covering large geographic areas. The goal of this set of reports is to improve the integration and acquisition of interagency data for the next comprehensive report.

Executive Summary

The purpose of the northern spotted owl (*Strix occidentalis caurina*) effectiveness monitoring plan is to assess trends in spotted owl populations and habitat. Monitoring data will be used to evaluate the success of the 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 land throughout the range of the owl.

The monitoring objectives are to (1) assess changes in population trend and demographic performance of spotted owls on federally administered forest land within the range of the owl, and (2) assess changes in the amount and distribution of nesting, roosting, and foraging habitat (owl habitat) and dispersal habitat for spotted owls on federally administered forest land.

Analyses of population data[1] indicated a 3.4 percent weighted average annual decline for owl populations in the 10 demographic areas associated with land managed under the Plan. Annual rate of population change was not calculated for the Marin study area because of the few years of data. The rates of decline differed between individual study areas. Populations were stationary (see "Glossary") or increasing in 3 of the 10 areas (all in southern Oregon) based on estimates of realized population change. For those areas showing annual declines, those in Washington showed the highest rate of decline—an average decline of 7.1 percent per year. Possible reasons for the declines include high densities of barred owls (*Strix varia*) in Washington and parts of Oregon, loss of habitat to wildfire, harvest of owl habitat, poor weather conditions, and forest defoliation by insect infestations (see footnote 1).

Analyses of habitat conditions on federal land were based on province-scale habitat suitability maps derived from vegetation base maps. About 74 percent of the federal land in the range of the owl was estimated as capable of producing owl habitat. The models used to derive the habitat condition maps depict a range of habitat-capable area from least similar to most similar to conditions of known territorial owl presence by using a scale of 0 to 100. Generally, habitat-capable area rated 41 to 100 has habitat conditions most similar to forest conditions known to be used by spotted owls. The habitat-capable area rated 0 to 40 has conditions dissimilar to known owl locations but is important because it has potential to be recruited into the range of conditions most similar to those with known owl presence. The monitoring results establish a baseline for tracking maintenance and restoration of habitat conditions related to owl presence.

[1] Anthony, R.G.; Forsman, E.D.; Franklin, A.B.; Anderson, D.R.; Burnham, K.P.; White, G.C.; Schwarz, C.J.; Nichols, J.; Hines, J.; Olson, G.S.; Ackers, S.H.; Andrews, S.; Biswell, B.L.; Carlson, P.C.; Diller, L.V.; Dugger, K.M.; Fehring, K.E.; Fleming, T.L.; Gerhardt, R.P.; Gremel, S.A.; Gutierrez, R.J.; Happe, P.J.; Herter, D.R.; Higley, J.M.: Horn, R.B.; Irwin, L.L.; Loschl, P.J.; Reid, J.A.; Sovern, S.G. 2004. Status and trends in demography of northern spotted owls, 1985–2003. Final report to the Regional Interagency Executive Committee. Portland, Oregon.

Rangewide (throughout the spotted owl range), about 57 percent of habitat-capable area was rated 41 to 100 at the beginning of the monitoring period. About 51 percent of the habitat-capable area occurs inside large, reserved blocks of federal land intended to support clusters of reproducing owls. Inside the blocks, about 62 percent of the habitat-capable area was rated 41 to 100 for habitat condition. We were able to account for loss of habitat in the 41 to 100 range resulting from stand-replacing timber harvest and wildfire: about 1.5 percent from both sources with wildfire accounting for over 80 percent of the habitat lost. We were unable to account for ingrowth of habitat.

Movement distances were calculated for 1,210 juvenile movement records and 1,388 nonjuvenile records in relation to the Plan's reserve network. Juvenile movements occurred from one reserved block to another (142 juveniles), from outside a reserved block to inside a reserved block (247 juveniles), and within a single reserved block (232 juveniles). All these movements had recovery points inside the reserved blocks and accounted for 51 percent of juvenile movement records.

Juvenile movements with recovery points outside the reserved blocks included 268 juveniles moving from a reserved block to outside of the block and another 321 that moved from outside a reserved block to another point outside a reserved block. These movements composed about 49 percent of the juvenile movement records.

Research on predicting owl survival and productivity in relation to habitat amount and arrangement has given us insight and understanding, but we are not in a position to shift from mark-recapture studies to increased reliance on habitat monitoring by using predictive models to indirectly estimate the demographic performance of spotted owls. The study of the relation of occupancy (occurrence) to habitat amount and arrangement is a work in progress with initial results expected in fall 2005.

Emerging issues that may need future management consideration are the apparent negative interaction between barred owls and spotted owls and the potential loss of individual owls to West Nile virus (*Flavivirus* sp.). Management of owl habitat in the drier, fire-prone provinces will continue to provide a challenge in the face of increasing risk of catastrophic fire and the need to assess short-term versus long-term effects on owl populations in these areas.

Contents

Frank Oliver

Chapter 1: Background

Joseph Lint[1] *and Jon Martin*[2]

In the early 1990s, controversy over harvest of old-growth forests led to sweeping changes in management of federal forests in western Washington and Oregon and northwest California. These changes were prompted by a series of lawsuits in the late 1980s and early 1990s, which effectively shut down federal timber harvest in the Pacific Northwest. In response, President Clinton convened a summit in Portland, Oregon, in 1993. At the summit, President Clinton issued a mandate for federal land management and regulatory agencies to work together to develop a plan to resolve the conflict. The President's guiding principles followed shortly after the summit in his Forest Plan for a Sustainable Economy and Sustainable Environment (Clinton and Gore 1996).

Immediately after the summit, a team of scientists and technical experts was convened to conduct an assessment of options (FEMAT 1993). This assessment provided the scientific basis for the Environmental Impact Statement and Record of Decision (ROD) (USDA USDI 1994) to amend Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl (*Strix occidentalis caurina*).

The ROD, covering 24 million federal ac, put in place a new approach to federal land management. Key components of the ROD included a new set of land use allocations—late-successional reserves, matrix, riparian reserves, adaptive management areas, and key watersheds. Plan standards and guidelines provided specific management direction regarding how these land use allocations were to be managed. In addition, the Plan put in place a variety of strategies and processes to be implemented. These included adaptive management, an aquatic conservation strategy, late-successional reserve and watershed assessments, a survey and manage program, an interagency organization, social and economic mitigation initiatives, and monitoring.

Monitoring provides a means to address the uncertainty of our predictions and compliance with forest management laws and policy. The ROD stated that monitoring is essential (USDA USDI 1994):

> Monitoring is an essential component of the selected alternative. It ensures that management actions meet the prescribed standards and guidelines and that they comply with applicable laws and policies. Monitoring will provide information to determine if the standards and guidelines are being followed, verify if they are achieving the desired results, and determine if underlying assumptions are sound.

Judge Dwyer (1994) reinforced the importance of monitoring in his decision declaring the Plan legally acceptable:

> Monitoring is central to the [Northwest Forest Plan's] validity. If it is not funded, or done for any reason, the plan will have to be reconsidered.

The ROD monitoring plan provided a very general framework to begin development of an interagency monitoring program. It identified key areas to monitor, initial sets of questions, types and scope of monitoring, the need for common protocols and quality assurance, and the need to develop a common design framework. In 1995, the effectiveness monitoring program plan (Mulder et al. 1995) and initial protocols for implementation monitoring (Alegria et al. 1995) were approved by the Regional Interagency Executive Committee. Approval of the effectiveness monitoring plan led to the formation of technical teams to develop the overall program strategy and design (Mulder et al. 1999) and monitoring protocols for late-successional and old-growth forests (Hemstrom et al. 1998), northern spotted owls (Lint et al. 1999), marbled murrelets (*Brachyrampus marmoratus*) (Madsen et al. 1999), tribal issues (USDA USDI 2002), and watershed condition (Reeves et al. 2004). Socioeconomic monitoring protocols continue to be tested (Charnley, in press).

[1] **Joseph Lint** is a wildlife biologist, U.S. Department of the Interior, Bureau of Land Management, Oregon State Office, 777 Garden Valley Blvd., NW, Roseburg, OR 97470. He is the module leader for northern spotted owl effectiveness monitoring under the Northwest Forest Plan.

[2] **Jon Martin** is the Assistant Director for Resource Planning and Monitoring in the Pacific Northwest Region, U.S. Department of Agriculture, Forest Service, 333 SW First Avenue, Portland, OR 97208. He is the Interagency Regional Monitoring Program Manager.

Periodic analysis and interpretation of monitoring data is essential to completing the monitoring task critical to completing the adaptive management cycle. This important step was described in the overall monitoring strategy (Mulder et al. 1999) and approved by the Regional Interagency Executive Committee. This 10-year report is the first comprehensive analysis and interpretation of monitoring data since the ROD.

The northern spotted owl was a species of interest when the Northwest Forest Plan (the Plan) was being developed in 1993–94. It was listed in 1990 as a threatened species under the Endangered Species Act of 1973, as amended (the act). The listing action invoked section 7(a)(1) of the act, which directed federal agencies to carry out programs to conserve endangered and threatened species. The Plan's record of decision reflected the direction in land use allocations and standards and guidelines intended to constitute the contributions of the USDA Forest Service (FS) and the USDI Bureau of Land Management (BLM) to the recovery of the northern spotted owl (USDA USDI, 1994: 31). The owl's recovery depends on improved status of the species so that listing under one or more of the criteria in section 4 (a)(1) of the act would no longer be appropriate. Maintaining and restoring habitat under the Plan are keys to improving the owl's status and placing it on a trajectory toward recovery and delisting.

The need to meet expectations for owl habitat and populations made monitoring an essential component of managing owls under the Plan. The ROD posed a primary evaluation question on spotted owls: Is the population stable or increasing? Monitoring results will aid federal managers in evaluating whether the Plan has succeeded in arresting the downward trend in the owl population and in maintaining and restoring habitat conditions needed to support viable populations on federally administered forest lands throughout the range of the owl (Lint et al. 1999). Monitoring will gauge the agencies' progress in providing the federal contribution to owl recovery.

Spotted owl monitoring (Lint et al. 1999) has incorporated a mix of monitoring actions and research studies to investigate the status and trend of the owl population and its habitat. The cornerstone of the strategy for effectiveness monitoring was assessing the owl's population and habitat (Lint et al. 1999). The monitoring program developed by Lint et al. (1999) comprises studying owl demographics, assessing its habitat, and developing predictive models to relate demographic variability to habitat variation at scales of the landscape and the owl's home range. Lint et al. (1999) provided this general description of the approach to monitoring the spotted owl:

> The plan [monitoring strategy] 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 using mark-recapture techniques. These methods yield detailed information on demographic performance and annual rate of population change (Burnham et al. 1996). In the latter part of Phase I, data on the abundance and demographic performance of owls will be combined with information on 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 will also 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 GIS format. Vegetation data layers will be overlaid to create a forest-class map from which an owl habitat map can be derived. The forest-class map will be a product from the Late-Successional/Old-Growth Effectiveness Monitoring Plan.
>
> Phase I will culminate with model validation based on data collected outside of the demographic study areas, in selected validation sites. Validation sites will compare the observed distribution and population numbers of owls with those predicted from the habitat models. Habitat condition will be initially

estimated for selected model-validation test areas by a probability-based selection of sites from the range wide habitat map. The models will be refined and evaluated for operational monitoring during Phase II.

If the predictive models produced in Phase I prove adequate, (i.e., provide predictions with an associated risk that is acceptable to decision-makers) they will replace the intensive owl surveys and multi-scale 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 studies 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 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 range-wide habitat monitoring effort does provide data of satisfactory resolution to track trend, then the habitat monitoring element will track changing conditions by demographic study area until such time that the range-wide effort is operational or another habitat monitoring strategy is adopted.

Since the Plan's adoption in 1994, the spotted owl monitoring program has implemented the components of Phase I. Population monitoring gathered information on owl occupancy, survival, and reproduction in demographic study areas in the owl's range. Habitat monitoring used owl habitat maps for each physiographic province (fig. 1-1) derived by modeling data on known owl locations and landscape vegetation condition. Phase I efforts also investigated the possibilities of predicting owl survival, productivity, and occupancy by using habitat characteristics. Our report provides the results of monitoring owl habitat and population monitoring, along with an update of the ongoing work on developing predictive models. The monitoring results measured changes in owl habitat and populations since the Plan's inception and established benchmarks for measuring changes from this point forward.

This report and its supporting documents, incorporated by reference, describe the key monitoring questions, data sources, data-compilation processes, analyses methods, and results for the three areas of interest: habitat, population, and predictive models. Guidance for data analysis and reporting in Lint et al. (1999) were to provide estimates of:

- Survival, reproductive success, and annual rate of population change for each demographic study area, as well as cumulatively, through a rangewide meta-analysis.
- Change in the amount and distribution of spotted owl habitat, by tabulating information about acres of habitat by land use allocation and examining the percentage of change over time.

References

Alegria, J.; Hyzer, M.; Mulder, B.; Schnoes, B.; Tolle, T. 1995. Guidance for implementation monitoring for management of habitat for late-successional and old-growth related species within the range of the northern spotted owl. Unpublished report. On file with: Regional Ecosystem Office, 333 SW First Avenue, Portland, OR 97204.

Burnham, K.P.; Anderson, D.R.; White, G.C. 1996. Meta-analysis of vital rates of the northern spotted owl. Studies in Avian Biology. 17: 92–101.

Charnley, S., tech. coord. [In press]. Northwest Forest Plan—the first 10 years (1994–2003): socioeconomic monitoring results. Gen. Tech. Rep. PNW-GTR-649. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 6 vol.

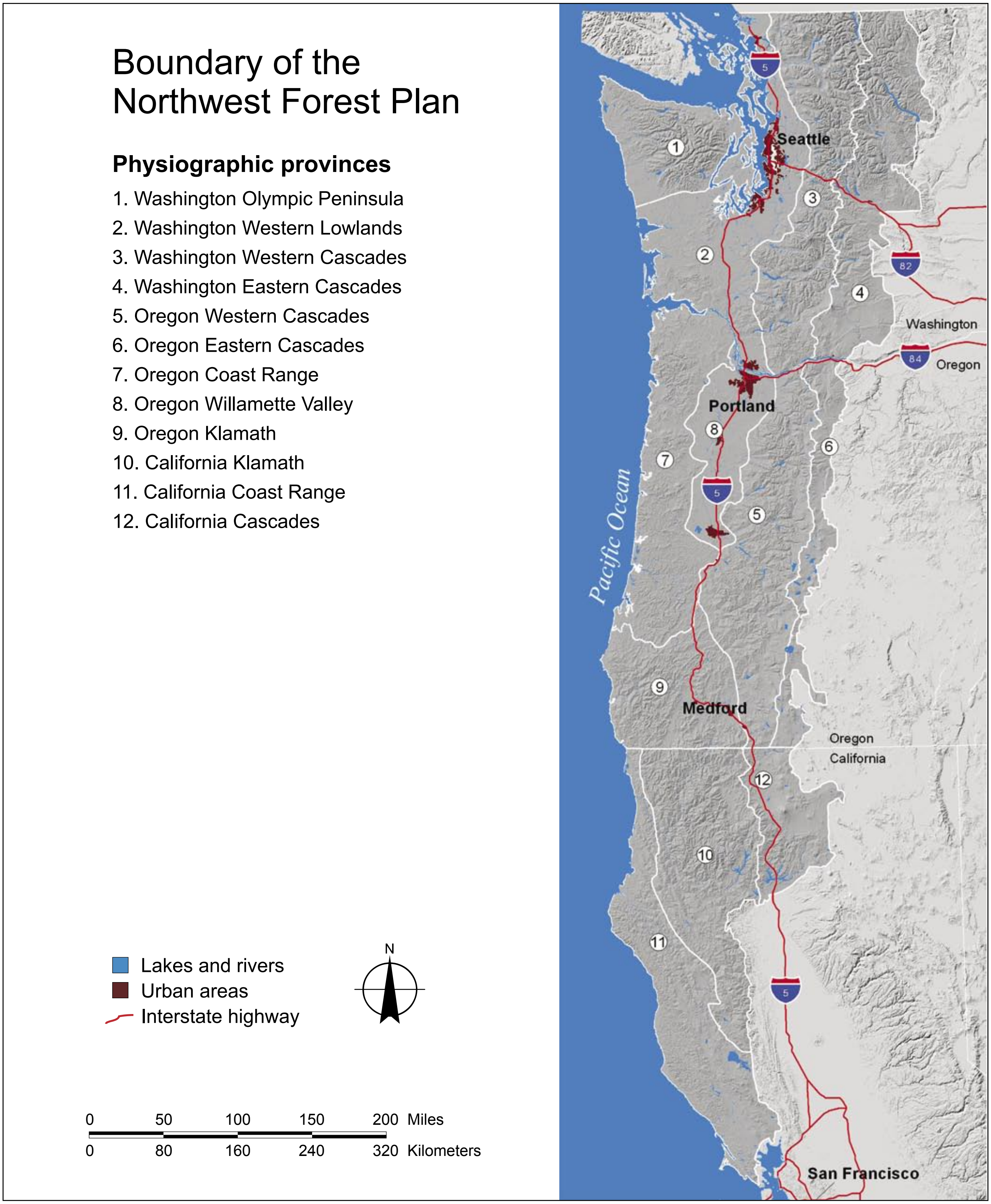

Figure 1-1—Physiographic provinces in the range of the northern spotted owl.

Clinton, W.J.; Gore, A., Jr. 1996. The forest plan for a sustainable economy and a sustainable environment. In: Tuchmann, E.T.; Connaughton, K.E; Freedman, L.E.; Moriwaki, C.B. The Northwest Forest Plan: a report to the President and Congress. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. Appendix A.

Dwyer, W.L. 1994. Seattle Audubon Society, et al. v. James Lyons, Assistant Secretary of Agriculture, et al. Order on motions for Summary Judgment RE 1994 Forest Plan. Seattle, WA: U.S. District Court, Western District of Washington.

Forest Ecosystem Management Assessment Team [FEMAT]. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior [and others]. [Irregular pagination].

Hemstrom, M.; Spies, T.; Palmer, C.; Kiester, R.; Teply, J.; McDonald, P.; Warbington, R. 1998. Late-successional and old-growth forest effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-438. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 37 p.

Lint, J.; Noon, B.; Anthony, R.; Forsman, E.; Raphael, M.; Collopy, M.; Starkey E. 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.

Madsen, S.; Evans, D.; Hamer, T.; Henson, P. ; Miller, S.; Nelson, S.K.; Roby, D.; Stapanian, M. 1999. Marbled murrelet effectiveness monitoring plan for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-439. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p.

Mulder, B.; Alegria, J.; Czaplewski, R.; Ringold, P.; Tolle, T. 1995. Effectiveness monitoring: an interagency program for the Northwest Forest Plan with an emphasis on late-successional forest, northern spotted owl, marbled murrelet, survey and manage, and riparian and aquatic. Portland, OR: Research and Monitoring Committee, Regional Ecosystem Office. 51 p + appendices.

Mulder, B.; Noon, B.; Spies, T.; Raphael, M.; Palmer, C.; Olsen, A.; Reeves, G.; Welsh, H. 1999. The strategy and design of the effectiveness monitoring program for the Northwest Forest Plan. Gen. Tech. Rep. PNW-GTR-437. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 138 p.

Reeves, G.; Hohler, D.; Larsen, D.; Busch, D.; Kratz, K.; Reynolds, K.; Stein, K.; Atzet, T.; Hays, P.; Tehan, M. 2004. Effectiveness monitoring for the aquatic and riparian component of the Northwest Forest Plan: conceptual framework and options. Gen. Tech. Rep. PNW-GTR-577. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 71 p.

U.S Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management. 1994. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Volumes 1–2 + Record of Decision.

U.S Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management. 2002. Tribal monitoring under the Northwest Forest Plan. Interagency executive letter. On file with: Regional Ecosystem Office, 333 SW First Avenue, Portland, OR 97204.

Scott Graham

Chapter 2: Population Status and Trend

Joseph Lint [1]

Introduction

The population component of the owl monitoring plan tackled this question: Will implementing the Northwest Forest Plan (the Plan) reverse the declining population trend and maintain the historical geographic range of the northern spotted owl (*Strix occidentalis caurina*)?

Population information to address this question came primarily from eight demographic study areas that were part of the federal effectiveness monitoring plan for the northern spotted owl (the monitoring plan) (Lint et al. 1999). Three additional study areas, independent of the monitoring plan, also provided relevant population data; their data are used because they include lands managed under the Plan. These 11 study areas were spread throughout the owl's range (fig. 2-1 and table 2-1). Data on owl occupancy, survival, and productivity were gathered annually from each study area to answer the question: What are the trends in rates of demographic performance in relation to adult survival, reproduction, and the annual rate of change of owl populations?

Results of the data analyses from the demographic study areas were reported by Anthony et al. (2004). The objectives of the population status and trend analyses were to:

- Estimate age-specific survival probabilities and fecundity rates, and their sampling variances, for individual study areas.
- Determine if any trends in adult female survival and fecundity exist across study areas.
- Estimate annual rates of population change (λ_{RJS}) and their sampling variances for individual study areas and across study areas.
- Examine the demographic performance of spotted owl populations on the eight areas that are the basis of the monitoring plan on federal lands (Lint et al. 1999).

Other pertinent questions examined by Anthony et al. (2004) were as follows:

- Were owl populations stationary (see "Glossary") during the period of study?
- Were rates of survival and reproduction changing over time?

[1] **Joseph Lint** is a wildlife biologist,U.S. Department of the Interior, Bureau of Land Management, Oregon State Office, 777 Garden Valley Blvd., NW, Roseburg, OR 97470. He is the module leader for northern spotted owl effectiveness monitoring under the Northwest Forest Plan.

Table 2-1—Eleven demographic study areas associated with land managed under the Northwest Forest Plan

Study area	State	Physiographic province	Years of study	Land management class	Study area size	Owls banded: Juveniles	Owls banded: Nonjuveniles	Owls banded: Total	Captures plus detections
					Square miles	*- - - Number*			*- - -*
Wenatchee	Washington	Eastern and Western Cascades	1990–2003	Mixed	1,795	752	448	1,200	2,556
Cle Elum[a]	Washington	Eastern Cascades	1989–2003	Mixed	689	502	222	724	1,570
Rainier	Washington	Western Cascades	1992–2003	Mixed	824	97	120	217	530
Olympic[a]	Washington	Olympic Peninsula	1987–2003	Federal	1,270	516	469	985	3,568
Coast Range[a]	Oregon	Coast Range	1990–2003	Mixed	1,513	574	451	1,025	3,386
Tyee[a]	Oregon	Coast Range	1985–2003	Mixed	672	610	422	1,032	3,293
H.J. Andrews[a]	Oregon	Western Cascades	1987–2003	Federal	589	602	493	1,095	3,151
Southern Cascades[a]	Oregon	Western Cascades	1991–2003	Federal	1,303	411	470	881	2,141
Klamath[a]	Oregon	Klamath	1985–2003	Mixed	534	698	449	1,147	2,964
NW California[a]	California	Klamath	1985–2003	Federal	691	609	417	1,026	2,865
Marin	California	Coast	1998–2003	Federal	84	41	55	96	225
Total					9,964	5,412	4,016	9,428	26,249

[a] Study area is one of eight monitored under the Northern Spotted Owl Effectiveness Monitoring Program for the Northwest Forest Plan.

Source: adapted from Anthony et al. 2004.

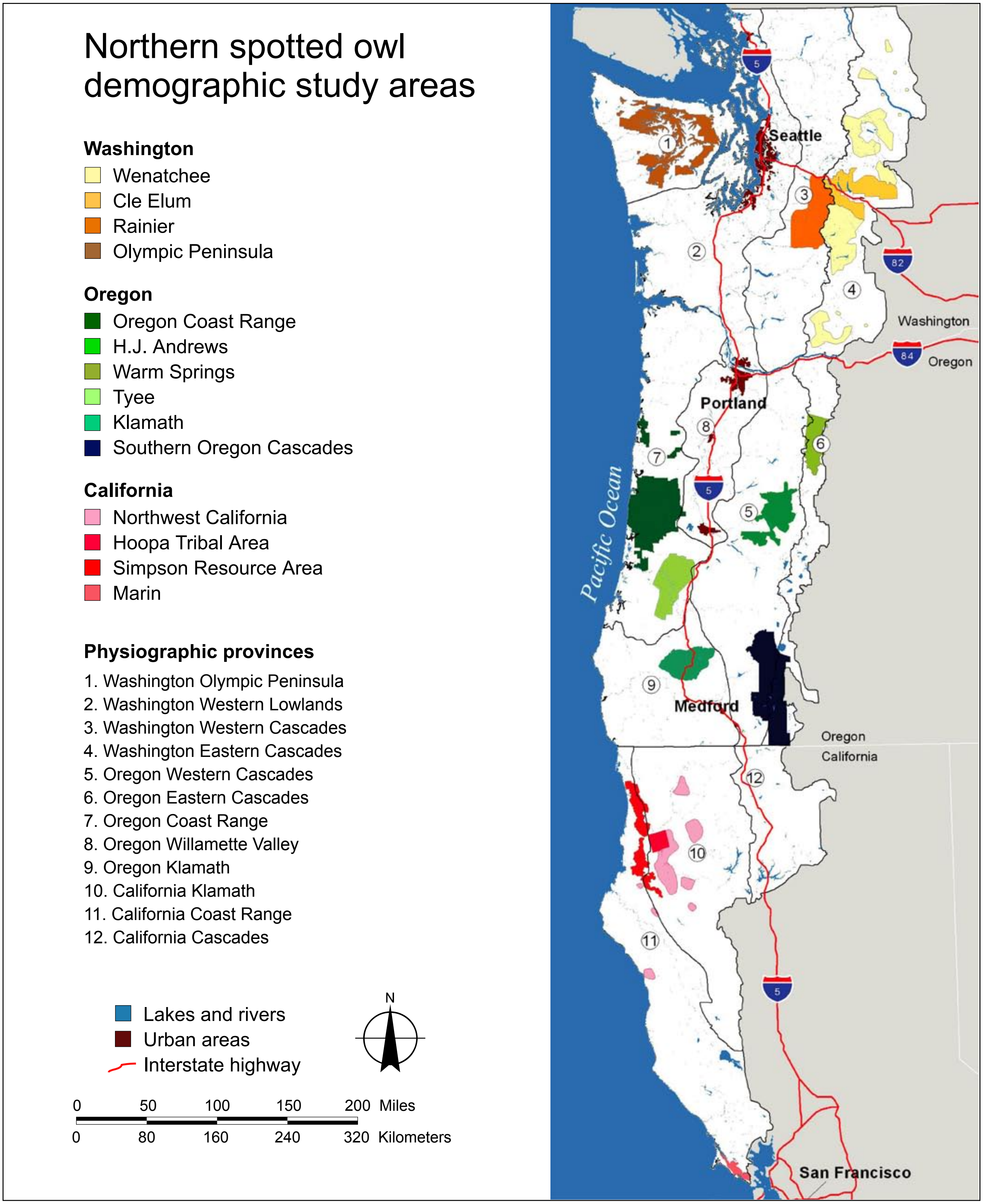

Figure 2-1—Location and boundaries of the northern spotted owl demographic study areas (from Anthony et al. 2004).

- Did barred owls (*Strix varia*) influence spotted owl survival or fecundity?

Spotted owl population status and trend were analyzed in 1991, 1993, 1998, and 2004. After 1993, the data were analyzed whenever additional 5-year increments were available. The 2004 analyses incorporated the complete data sets for the eight demographic areas under the monitoring plan as well as for six other independent demographic study areas in the owl's range (Anthony et al. 2004). Results from the subset of the 11 study areas associated with federal lands were used in our monitoring report. Annual rate of population change was not calculated for the Marin study area, one of the three additional study areas, because of the few years of data.

Data Sources and Methods

The analysis of status and trends of the owl populations on federal lands in the Plan area relied on 11 demographic study areas (fig. 2-1). Eight of the 11 study areas—the Olympic Peninsula and Cle Elum in Washington; the H.J. Andrews, Southern Cascades, Coast Range, Klamath, and Tyee in Oregon; and Northwest California—were part of this monitoring plan (Lint et al. 1999). The other three study areas—Rainier and Wenatchee in Washington and Marin in California (fig. 2-1)—were independent of the monitoring plan. Because they are on federal lands in the Plan area, they provide additional data to assess the Plan's effectiveness. The three remaining study areas are the Warm Springs and Hoopa on tribal lands and the Simpson located on private timber company lands. These three areas, along with the 11 mentioned above were part of the rangewide status and trend analyses by Anthony et al. (2004). Because they had no land managed under the Plan, they were not included in this monitoring report except when results for all 14 study areas are provided.

The size of the 11 study areas ranged from 84 to 1,795 mi^2. The median study area size was 691 mi^2 and the mean size was 906 mi^2 (table 2-1). Together, the study areas covered 9,964 mi^2, or about 11 percent of the owl's range.

The periods covered by the data sets from the study areas ranged from 6 to 19 years. The study areas were primarily federal lands managed by the USDA Forest Service (FS), USDI Bureau of Land Management (BLM), and the USDI National Park Service (NPS). In some study areas, nonfederal lands, mainly owned by private timber companies, were intermingled with the federal lands, forming a checkerboard pattern of mixed ownership.

Collecting Field Data

Population data were collected annually in the field in each of the 11 demographic study areas. Biologists attempted to find and mark all spotted owls in each study area. They observed the marked owls by using standardized techniques to determine the age, sex, and reproductive status of individuals and to estimate the reproductive output by counting the number of young fledged (Franklin et al. 1996). For additional information on the field methods for surveying, determining of sex and age, capturing, marking, and estimating reproductive output, refer to Franklin et al. (1996) and Lint et al. (1999).

Analyzing Population Status and Trend

The status and trends of northern spotted owl populations in the demographic study areas were analyzed during an 8-day (January 4 through January 11, 2004) workshop in Corvallis, Oregon. Some followup analyses and a workshop report were completed after the workshop. The workshop's format followed the protocol for analyzing empirical data related to natural resource issues described by Anderson et al. (1999). Senior analysts with recognized expertise in population dynamics, statistics, and the analysis of capture-recapture data led the workshop and guided the analysis (app. A). The final, peer-reviewed results of the analyses are reported in Anthony et al. (2004).

Before the workshop, the empirical data from each of the demographic study areas were summarized and compiled into three data files for analysis: one was used for estimating age- and sex-specific survival, one for estimating age- and sex-specific fecundity, and the third for estimating population rates of change from marked, territorial owls.

The next four sections on developing data files and error-checking of data files, were summarized from the pre-workshop directions and guidelines sent to the principal investigators of the demographic study areas by the workshop's organizers (Forsman 2003).

Developing Data Files for Survival Analysis

The data file for survival-rate analysis was derived from a detailed capture-history matrix. Each record in the database represented a capture history for an individual owl. The capture histories for individual owls were built by using a system of ones and zeros. A "1" in the column for a specific year denoted an owl identified in that year, and a "0" in the column for the following year indicated the owl was not identified that year. The resulting capture strings of 1s and 0s (such as 1 0 0 0 0 1 1 1 1 0) showed the capture history for successive years after the initial capture.

Developing Data Files for Fecundity Analysis

The fecundity database provided annual information on the occupancy status of the owl territory (site), the age of the owls present at the site, and the number of young fledged. Occupancy status reflects whether the site was occupied by a single male, single female, or a pair of owls. One record was created for each occupied site for each year, and the age of each owl was recorded.

Spotted owl sites were checked annually, and the number of young seen out of the nest tree (fledged) was recorded. Documentation of the number of young fledged was based on a minimum of two visits to count the young after the date young were generally known to leave the nest tree in that geographic area. Techniques used to characterize the reproductive output of individual territorial owls are described in Franklin et al. (1996) and Lint et al. (1999).

Checking for Errors in the Survival and Fecundity Database Files

Compilation of the survival and fecundity database files was designed to ensure that all files were built correctly and that the field data supported the data in the digital files. All study-area leaders were provided with instructions for entering data in the analysis files. When the files were completed, they were checked for errors by members of the workshop-organizing team not associated with that specific data set.

The capture-history files were error-checked by randomly drawing 10 capture histories from each study-area file. The principal investigators were required to provide paper copies of the field-data forms that supported each capture history.

For the fecundity-file error check, 10 records were selected at random from each study-area file. Again, the principal investigators were required to provide paper copies of the field-data forms that supported the data record of reproductive success in a given year for a specific female.

If errors were found in the first round of error checking, another sample of 10 records was selected and the process was repeated. If errors were found in the second round of error checking, the principal investigator was directed to review the whole data file for errors. The sequence of error checking and data review was repeated until a set of 10 randomly drawn records were without error. Copies of the error-checked records along with copies of the field-data forms submitted to confirm those records, were archived. Principal investigators signed statements before the data analyses to certify their data were accurate and ready for analysis.

Developing Data Files for Analyzing Rates of Population Change

The analyses of rates of population change (λ) used a modified version of the capture-history matrix derived from the certified database file for survival analysis. The Reparameterized Jolly-Seber method (λ_{RJS}) was used to estimate the annual rates of population change (λ) (Nichols et al. 2000, Pradel 1996).

The analysis of apparent survival (ϕ) was restricted to territorial individuals (that is, nonjuveniles) and included both subadults and adults. Estimates of juvenile survival and fecundity were not needed to estimate λ_{RJS}; thus the problems associated with estimating those parameters in previous analyses were eliminated. Other limitations existed, however, such as spatial variability in the survey effort. For example, some portions of a study area may not have been as completely surveyed as others. If many owls were initially missed in these areas and later found, λ can be biased high because the individuals would be considered new recruits when they were already present in the population. Because of the temporal variability of spatial survey effort, the capture-history matrices used in this analysis came from a fixed area with relatively constant survey effort.

Conventions for selecting the study area for analysis included the rule that sites or geographic areas could not be removed from the study area over time. Sites could have been added or the land area expanded during the course of the study, but only once, and on the condition that the expanded area was surveyed consistently for the remainder of the study.

The capture histories used in the analysis of λ_{RJS} were from territorial individuals, either male or female. This data file was developed from the original capture histories. Owls that were initially captured as juveniles, but never recaptured, or were first recaptured off the study area of interest, were eliminated from the data file. For those birds initially captured as juveniles and later recaptured on the study area of interest, the juvenile portion of the capture history was eliminated and only the portion after the first recapture was retained.

The principal investigators submitted descriptions of the sampling periods, the study areas, and a study area boundary map. The description also explained why the particular years and study areas were chosen and why they represented an area with reasonably consistent survey effort. Any expansion of study areas was also described with the approximate number of sites added. The maps showed the geographic location of each study area with original and expanded boundaries of the study areas delineated, where appropriate.

Two final preparatory steps—testing for goodness-of-fit to the Cormack-Jolly-Seber model and over-dispersion on the capture-recapture data and establishing agreed-upon analysis protocols among the principal investigators and analysts—were completed before the beginning of the analyses (Anthony et al. 2004).

Estimating Apparent Annual Survival

The general approach (Anthony et al. 2004) used to analyze the capture-recapture data for survival estimates was to:

- Determine a set of a priori models to analyze.
- Evaluate goodness-of-fit and estimate an over-dispersion parameter (c) for each data set.
- Estimate the capture probabilities and apparent survival for each capture-recapture data set with the models developed in the first step by using program MARK (White and Burnham 1999).
- Adjust the covariance matrices and corrected Akaike's information criterion (AICc) values with the over-dispersion parameter to obtain corrected quasi-Akaike's information criterion (QAICc) values (White et al. 2001).
- Select an appropriate model for inference based on QAICc model selection (Burnham and Anderson 2002).

Discussions of the approach to estimating survival for individual study areas, as well as the meta-analysis of trends in survival, were presented in Anthony et al. (2004) and Franklin et al. (1996).

Anthony et al. (2004) also conducted meta-analyses of apparent survival by using ownership, geographic region, ownership with region interaction, and latitude in 27 model combinations. The criteria for the groups were explained in Anthony et al. (2004).

Estimating Fecundity

The estimation of fecundity used annual data from each demographic study area to determine the number of young fledged per territorial female. These data included the number of young fledged, study area, the owl territory name, the year, and age of the female (Anthony et al. 2004).

The fecundity data were analyzed under a maximum likelihood framework by using mixed models. This step was needed to account for a possible lack of independence in the data caused by females breeding on the same territory for many years (Anthony et al. 2004). The models applied to each study-area data set included the effects of age class, time, barred owls, even-odd years, land ownership, and geographic region (Anthony et al. 2004). The even-odd-year effect was the result of a cyclic pattern in the number of young fledged, with more in even years. (Anthony et al. 2004).

Separate meta-analysis of the fecundity data used all eight monitoring plan demographic study areas. In the meta-analysis, the relations between geographic regions and land-ownership categories were also included (Anthony et al. 2004). The authors noted that a key feature of the meta-analysis was that the experimental units were year and region, not the individual females. The birds were sub-samples in region-with-year interaction treatments applied to each demographic study area, so the study areas are the experimental units. A discussion of the methods used for estimating fecundity is provided in Anthony et al. (2004).

Estimating Annual Rate of Population Change

The population change analyses determined whether spotted owl populations in the demographic study areas were stationary, increasing, or decreasing. If they were increasing or decreasing, the annual rate of change was of interest. The Reparameterized Jolly-Seber method (λ_{RJS}) was used to estimate the annual rates of population change (λ) (Nichols et al. 2000, Pradel 1996). A time-specific λ_{RJS} was estimated from annual capture-history data from the individual demographic study areas. This estimate, based on survival and recruitment, reflected changes in population size resulting from reproduction, mortality, and movement (Anthony et al. 2004). Additional discussions of the method are in Anthony et al. (2004) and Pradel (1996).

Estimating Realized Population Change

Anthony et al. (2004) estimated the trajectory of the population, over time, by translating the annual estimates of λ for each study area into estimates of the realized change. This analysis provides understanding of how annual estimates of λ affect the trends in populations over time (Anthony et al. 2004). The realized change was expressed as the percentage of the initial population present at the beginning of each study that was present in 2003. They provided the example that for year-specific lambdas of 0.9 (1993), 1.2 (1994), and 0.7 (1995). The realized change would be $0.9 \times 1.2 \times 0.7 = 0.756$. This product indicated that the population in 1995 was 75.6 percent of the starting population in 1993. It also shows that a λ greater than 1.0 (increasing population) in one year (1994) may not compensate for lambdas in other years that are below 1.0 (decreasing population) resulting in a population decline over time.

Results

These results are a summary of the findings from the analyses of survival rates, fecundity rates, annual rate of population change, and estimated realized population change for the northern spotted owl reported by Anthony et al. (2004). Anthony et al. (2004) noted that the results of their analyses cannot be considered representative of demographic trends of spotted owls throughout the range because the study areas were not randomly selected and did not include all portions of the range. However, they stated the belief that their results are representative of most populations on federal land in the United States because the study areas were large, covered much of the owl's geographic range, and included a variety of land ownerships and management strategies. Unless otherwise stated, the information reported pertains to the 11 demography study areas associated with federal land managed under the Plan. The report by Anthony et al. (2004), in particular, the discussion section, complements this summary.

Survival

Estimates of survival rates for spotted owls in the individual study areas differed by age class, and they were slightly higher for older owls. Estimated survival rates for 1-year-old owls ranged from 0.42 to 0.86, and for 2-year-olds from 0.63 to 0.89. For adult owls >2 years old, the estimated survival rates ranged from 0.75 to 0.91 (table 2-2). For the Plan study areas, survival for adults was >0.85 in all areas except Wenatchee and Rainier, and for adult female owls in the Marin study area.

Declines in survival, over time, were detected in the Wenatchee, Cle Elum, Rainier, Olympic Peninsula, and Northwest California study areas. These declines are important because annual rates of population change have

Table 2-2—Survival rates for northern spotted owls by age class in the 11 Northwest Forest Plan demographic study areas

			Age class					
			1 year old		2 years old		≥3 years old	
Study area	State	Landowner class	Survival	Std. error	Survival	Std. error	Survival	Std. error
			Percent					
Wenatchee	Washington	Mixed	0.626	0.073	0.626	0.073	0.750	0.026
Cle Elum[a]	Washington	Mixed	.860	.017	.860	.017	.860	.017
Rainier	Washington	Mixed	.832	.020	.832	.020	.832	.020
Olympic[a]	Washington	Federal	.570	.117	.855	.011	.855	.011
Coast Range[a]	Oregon	Mixed	.721	.107	.886	.010	.886	.010
Tyee[a]	Oregon	Mixed	.817	.042	.878	.011	.878	.011
H.J. Andrews[a]	Oregon	Federal	.415	.111	.883	.010	.883	.015
Southern Cascades[a]	Oregon	Federal	.725	.079	.725	.079	.854	.014
Klamath[a]	Oregon	Mixed	.849	.009	.849	.009	.849	.009
NW California[a]	California	Federal	.810	.027	.810	.027	.869	.011
Marin	California	Federal	.913[b]	.035	.913[b]	.035	.913[b]	.035
			.824[c]	.045	.824[c]	.045	.824[c]	.045

[a] Study area is one of eight monitored under the Northern Spotted Owl Effectiveness Monitoring Program for the Northwest Forest Plan.
[b] Male survival rate for Marin study area; survival rates for male and female are the same for other study areas.
[c] Female survival rate for Marin study area; survival rates for male and female are the same for other study areas.
Source: adapted from Anthony et al. 2004.

been found most sensitive to changes in adult survival. One of the keys to stationary populations is having high (>0.85), nondeclining, adult survival.

Results from the meta-analysis for the eight monitoring-plan demography areas failed to show any effect on survival from sex, ownership, or latitude. The survival effects noted were due to geographic region (for example, Washington Douglas-fir areas or Oregon/California mixed-conifer areas) and time. Study areas in the mixed-conifer and Douglas-fir zones in Washington showed a major downward trend in survival, which was consistent with the declines in survival noted for all four of the individual study areas in Washington.

The exploratory barred owl covariate was not a good predictor of apparent survival. Although strong evidence of a negative effect of barred owls on survival appeared in some study areas in Washington, a positive effect was found for the Southern Cascades study area in Oregon. The Southern Cascades finding was opposite the authors' hypothesis and may be a spurious result, as barred owls occurred at less than 10 percent of spotted owl territories in the study area during most of the study period.

Fecundity

Most of the fecundity information was from spotted owl territories occupied by adult females, with low frequency of occupation and breeding attempts by young females. The instances of 1- and 2-year-old female owls on territories accounted for only about 10 percent of the females sampled. Fecundity for 1-year-olds was 0.074 and for 2-year-olds, only 0.208. Age was the primary factor affecting fecundity, with adults having the highest fecundity of 0.372.

Of the 11 study areas in the Plan's area, the four with the highest adult fecundity were Cle Elum (0.574), Marin (0.530), Wenatchee (0.491), and Klamath (0.445) (table 2-3). The lowest estimated adult fecundity rates were in the Rainier (0.253), Oregon Coast (0.260), and Olympic Peninsula (0.293) study areas. For the eight monitoring-plan study areas, Cle Elum and Klamath had the highest estimated fecundity rates, and the Olympic and Oregon Coast Range study areas had the lowest.

Variability in fecundity was partially explained by age and the even-odd year effects. Fecundity was high in even-numbered years and low in odd-numbered years. This effect was strongest in the decade after 1990 and less evident after

Table 2-3—Fecundity (young fledged per territorial female) rates of northern spotted owls by age class in the 11 demographic study areas for the Northwest Forest Plan

			Age class					
			1 year old		2 years old		≥3 years old	
Study area	State	Landowner class	Mean	Std. error	Mean	Std. error	Mean	Std. error
			Percent					
Wenatchee	Washington	Mixed	0.050	0.050	0.290	0.085	0.491	0.058
Cle Elum[a]	Washington	Mixed	.136	.097	.467	.117	.574	.069
Rainier	Washington	Mixed	.000	.000	.000	.000	.253	.061
Olympic[a]	Washington	Federal	.071	.050	.267	.098	.293	.057
Coast Range[a]	Oregon	Mixed	.000	.000	.111	.045	.260	.050
Tyee[a]	Oregon	Mixed	.054	.032	.201	.047	.319	.040
H.J. Andrews[a]	Oregon	Federal	.109	.091	.113	.060	.321	.045
Southern Cascades[a]	Oregon	Federal	.061	.046	.223	.082	.377	.059
Klamath[a]	Oregon	Mixed	.070	.028	.285	.052	.445	.040
NW California[a]	California	Federal	.101	.066	.205	.052	.333	.032
Marin	California	Federal	.275	.195	.271	.159	.530	.056

[a] Study area is one of eight monitored under the Northern Spotted Owl Effectiveness Monitoring Program for the Northwest Forest Plan.
Source: adapted from Anthony et al. 2004.

2001. The fecundity trend for the 11 Plan-related study areas was stationary for 6 study areas, decreasing for 4 areas, and increasing on 1 of the areas (table 2-4). For the eight monitoring-plan study areas, four had a decreasing trend and the other four were either stationary (3) or increasing (1).

The analyses using the barred owl covariate did not show any negative effects of barred owls on spotted owl fecundity, but the authors pointed out that the barred owl variable used in the analyses was year-specific, so it was coarse-grained and lacked the specificity to individual nest sites that may have been needed to fully evaluate the effect of barred owls on spotted owl fecundity.

The meta-analysis for the eight demographic areas under the monitoring plan indicated that the additive effect of geographic region and time was important in explaining the fecundity data. Land-ownership effect had little weight, as did the barred owl covariate. Fecundity for the eight monitoring-plan areas was highest in the mixed-conifer zone in Washington (0.596) followed, in descending order, by the Oregon/California mixed conifer (0.380), the Oregon Cascades Douglas-fir (0.373), the Washington Douglas-fir (0.310), and the Oregon Coastal Douglas-fir (0.306) regions. For the expanded analysis using all 14 study areas, the highest fecundity was, once again, in the mixed-conifer zone in Washington (0.590). The second-highest fecundity was in the California Coast region (0.442) on Simpson Timber Company lands. None of the 11 Plan-related data sets was in the California Coast region, however.

Annual Rate of Population Change

The annual rate of population change (λ_{RJS}) was calculated for 10 of the 11 study areas associated with Plan-managed federal lands. Because of the few years of data for the Marin study area, no annual rate of population change was calculated. Estimates of λ_{RJS}, for the remaining 10 Plan-related study areas ranged from 0.896 to 1.005 (table 2-4 and fig. 2-2).

The point estimates of λ for all areas but one, Tyee, were under 1.0. Populations in the Tyee, Klamath, and Southern Cascades study areas in Oregon were stationary during the study period, based upon the 95-percent confidence interval. These three study areas were in the southern half of the spotted owl's range. The two study areas with λ_{RJS} values significantly <1.0 (declining population) were Wenatchee and Cle Elum in Washington. The Rainier and Olympic Peninsula study areas in Washington, the Oregon Coast and H.J. Andrews study areas in Oregon, and the Northwest California study area also showed population declines. Six of these seven study areas were in the northern half of the range of the owl.

Table 2-4—Trends of fecundity, survival, and population for the 11 demographic study areas associated with land managed under the Northwest Forest Plan

Study area	State	Landowner class	Fecundity	Survival	λ_{RJS} Mean	SE	95% CI	Population trend (from estimates of realized population change)
Wenatchee	Washington	Mixed	Stable	Declining	0.917	0.018	0.882–0.952	Declining
Cle Elum[a]	Washington	Mixed	Declining	Declining	.938	.019	.901–.976	Declining
Rainier	Washington	Mixed	Stable	Declining	.896	.055	.788–.003	Declining
Olympic[a]	Washington	Federal	Stable	Declining	.956	.032	.893–1.018	Declining
Coast Range[a]	Oregon	Mixed	Declining	Stable	.968	.018	.932–1.004	Declining
Tyee[a]	Oregon	Mixed	Increasing	Stable	1.005	.019	.967–1.043	Stationary
H.J. Andrews[a]	Oregon	Federal	Stable	Stable	.978	.014	.950–1.005	Declining
Southern Cascades[a]	Oregon	Federal	Declining	Stable	.974	.035	.906–1.042	Stationary
Klamath[a]	Oregon	Mixed	Stable	Stable	.997	.034	.930–1.063	Stationary
NW California[a]	California	Federal	Declining	Declining	.985	.013	.959–1.011	Declining
Marin	California	Federal	Stable	Stable	NA	NA	NA	NA
Weighted mean λ_{RJS} for all areas					**0.966**[b]	**0.0097**		
Weighted mean λ_{RJS} for 8 monitoring plan areas					**0.976**	**0.007**		

Note: NA= not available.

λ_{RJS} = reparameterized Jolly-Seber estimate of rate of population change.

[a] Study area is one of eight areas monitored under the Northern Spotted Owl Effectiveness Monitoring Program for the Northwest Forest Plan.

[b] Weighted mean for λ calculated by using same method as Anthony et al. 2004 (Olson 2004).

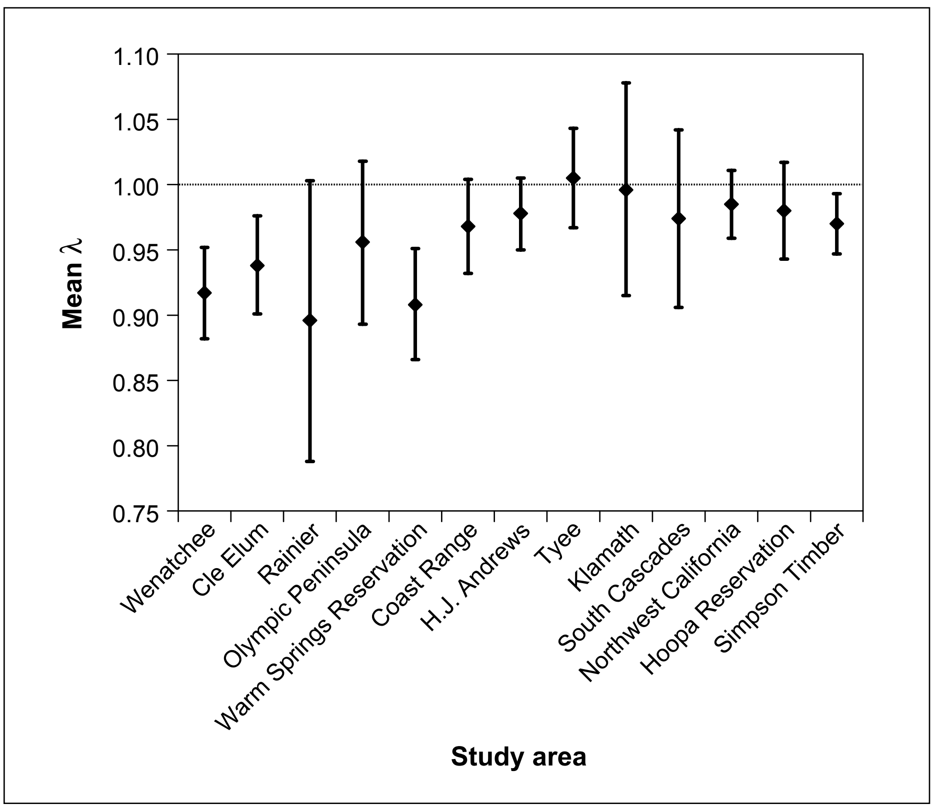

Figure 2-2—Estimates of mean lambda from reparameterized Jolly-Seber analysis for northern spotted owls on 13 study areas in Washington, Oregon, and California (from Anthony et al. 2004, fig. 7).

The weighted mean λ_{RJS} for the 10 areas was 0.9660 (SE = 0.0097), which equated to an average decline of about 3.4 percent annually (Olson 2004). The subset of eight study areas under the monitoring plan showed an estimated weighted average annual decline of 2.4 percent. Of the eight monitoring plan areas, Cle Elum, Olympic Peninsula, Oregon Coast Range, H.J. Andrews, and Northwest California showed declines, whereas the other three were relatively stationary (table 2-4). The weighted mean λ_{RJS} for all 14 of the study areas in the owl's range indicated a 3.7-percent average annual decline per year for the study period.

Realized Population Change

The realized population change estimate represented the trend in the proportion of the population remaining each year, given the initial population based on changes in λ_{RJS} over time (Anthony et al. 2004, fig. 11a–11c). Population trends for the 10 areas (Marin not included) under the Plan are summarized in table 2-4. Populations in 7 of the 10 (Cle Elum, Wenatchee, Olympic, Rainier, H.J. Andrews, Oregon Coast Range, and Northwest California) study areas declined over the past decade. The decline was most prevalent in Cle Elum, Wenatchee, and Rainier, where only 40 to 60 percent of the initial populations remain. Declines in the Olympic, H.J. Andrews, and Oregon Coast Range were not as steep but still resulted in the loss of 20 to 30 percent of the populations present in those areas. The populations in the Klamath, Tyee, and Southern Cascades were stationary.

Discussion and Conclusions

The Plan's final supplemental environmental impact statement (FSEIS) (USDA USDI 1994: 3&4–212) discussed results from the 1993 spotted owl population status and trend analysis. The 1993 analyses estimated the owl population was declining at about 4.5 percent per year (λ = 0.9548, 95 percent CI = 0.9162 to 0.9934). The FSEIS stated these results were "not surprising" given that the 1990 federal listing of the northern spotted owl was due to declining habitat with a strong inference that populations were also declining. The FSEIS went on to state "Given this history, it would be surprising if the rate of population growth of owls was equal to or greater than 1.0 with a stable population structure." Both Thomas et al. (1990) and the Northern Spotted Owl Recovery Team (USDI 1992) projected that "habitat and owls would continue to decline for up to 50 years before reaching a new equilibrium." Like these strategies, the prognosis of population trend under the Plan was general, providing a qualitative rather than quantitative expectation of population trajectory.

The results from the first 10 years of population monitoring under the Plan were both expected and unexpected. First, results from the realized population change analysis for 3 of the 10 study areas, all in southern Oregon, indicated stationary populations in those study areas. The fact that owl populations in some portions of the range were stationary was not expected just 10 years into the Plan given the general prediction of continued declines in the population in the first several decades of implementation. However, the average rate of population change across the range for Plan-managed lands showed an average decline of 3.4 percent. Anthony et al. (2004) pointed out that the rate of decline in some of the study areas was noteworthy, particularly the precipitous declines for the four study areas in Washington. The 7.1 percent average annual rate of decline for the four study areas in Washington was not gradual. The average annual rate of decline for study areas outside of Washington was 1.7 percent and more representative of a gradual rate of decline. The Plan FSEIS (USDA USDI 1994: 3&4–233) stated:

> The actual rate of decline should be considered when thinking about the likelihood of decline continuing into the future. If the average decline projected from the demographic, about 4.5 percent per year, were to continue into the future, then the population would be reduced by half in about 15 years. This rate of decline could have very serious consequences in the near future.

A population declining at 7 percent per year will have only about 34 percent of the initial population remaining after 15 years. A population declining at 1.7 percent per year will be about 77 percent of the initial level after 15 years. Anthony et al. (2004) stated that any predictions about past or future population trajectories for the populations they studied are not recommended. But, as discussed in the FSEIS in 1994, the actual rates of decline should be considered when thinking about the likelihood that decline may continue. In light of the annual rate of decline observed in Washington (7.1 percent) compared to the Plan-related study areas in the remainder of the range (1.7 percent), concern for the magnitude and direction of future population changes is greatest in Washington.

Anthony et al. (2004) postulated that possible causes for declines in owl survival and populations may include high density of barred owls in study areas in Washington and parts of Oregon, loss of habitat from wildfire and harvest, poor weather conditions, and forest defoliation from insect outbreaks. They gave examples of harvest of owl habitat on nonfederal lands in the Cle Elum study area between 1990 and 2003 and wildfires in the Wenatchee study area during the same period. They also pointed out that population declines may have been due to the lag effect from loss of habitat in earlier decades from timber harvest and wildfire. The available information allows only speculation on the factors that may be involved and permits no assignment of degree or magnitude of effect on the population. Heading the list of possible factors in Washington is the presence of the barred owl throughout the spotted owl's range in the state. Evidence of displacement of spotted owls by barred owls has been anecdotally noted in Washington and Oregon, but the territory-specific analyses and competitive interaction studies recommended by Anthony et al. (2004) may be needed to better assess the influence of barred owls on spotted owls.

The Plan FSEIS noted that the basis was not as strong for believing that owl populations have passed or will soon pass some threshold that would result in extirpation of the species from large parts of its range. The primary support for that conclusion was the evidence of population declines from the demography studies. Caution was given not to project these declines into the future because habitat loss, which was believed to have caused the population decline, would be dramatically slowed by any of the alternatives analyzed in the FSEIS. In addition, personal communications with the principal investigators in the demography areas indicated that none had seen evidence either in the form of available data or field knowledge to indicate that the owl populations in their study areas have passed or will soon pass a threshold leading to irreversible decline.

Ten years have passed since the Plan FSEIS assessment on spotted owls. The first decade of the future they wrote about is now the decade of Plan implementation that was monitored. Their concern for projecting into the future for the first decade has passed; the results are known. The FSEIS offered a number of reasons for believing the accelerating rates of population decline detected in the demographic studies in 1993 should not have been projected into the future. First, there was evidence that population trend was not the same across the range, and some portions of the range were thought to be closer to stability than indicated by the combined results for all the study areas. Ten years later, we see this prognosis was correct. Anthony et al. (2004) stated that populations appeared to be stationary in four study areas (three associated with federal lands) as a result of high survival and stable fecundity rates. Second, the FSEIS offered that late-successional reserves might be valuable as source areas for owl populations even if populations declined during the transition period. After the first decade, the reserve network prescribed under the Plan remains in place and has been effective in maintaining and restoring habitat as evidenced by the fact that about 98 percent of the habitat-capable area in the large reserved blocks was unaffected by stand-replacing timber harvest or wildfire (table 3-13, chapter 3 of this report). Third, the reserves were distributed across the full range of environmental conditions. This distribution remains an integral part of the Plan. Some loss has occurred in the reserves owing to wildfire, but it was limited to local areas in a few provinces. Habitat loss on federal land was markedly reduced in the first 10 years of the Plan, but population declines in Washington during the same period may be a signal of an uncertain future despite efforts to maintain and restore habitat.

The magnitude of population declines in Washington does not immediately translate into a failure of the Plan. The Plan is habitat-based. The maintenance and restoration of habitat is the action element of the Plan. Although management of forest stands in the reserves is a proactive approach to habitat restoration, the long-term gains in habitat restoration will be produced by forest succession, a passive agent of change. Habitat is a key element in the management of spotted owls, but it may not be the primary factor affecting population stability in either the short or long term. The Plan is maintaining and restoring habitat, but habitat is also being removed under the Plan. It is likely too soon to detect the benefits of habitat management under the plan from demographic data. There is also the additional complication that owl population response is influenced by a combination of factors, not just habitat. Even so, habitat remains a key foundation element for the conservation and recovery of the spotted owl.

Will implementing the Plan reverse the declining population trend and maintain the historical geographic range of the northern spotted owl? Based on the results of the first decade of monitoring we cannot answer this question because not enough time has passed to provide the necessary measure of certainty. However, the results from the first decade of monitoring do not provide any reason to depart from the objective of habitat maintenance and restoration as described under the Plan. The Plan's contribution to habitat management remains a cornerstone of the conservation and recovery of the spotted owl, but future spotted owl conservation efforts may need to address more than habitat management. The "maintain and restore [habitat] and they will come" approach seemed to be the straightforward solution a decade ago when habitat loss was a primary reason for listing the owls as a threatened species. We recognize that other stressors, some already in action (barred owl) and some yet to be realized (West Nile virus), may complicate the conservation and recovery of the spotted owl. Habitat maintenance and restoration, as currently envisioned under the Plan, remain essential to owl recovery and will continue, but in the near term, new partners, old partners with new roles, new discussions, and new initiatives must address the other stressors and how they may change our goals and objectives for spotted owl conservation.

References

Anderson, D.R.; Burnham, K.P.; Franklin, A.B.; Gutiérrez, R.J.; Forsman, E.D.; Anthony, R.G.; White, G.C.; Shenk, T.M. 1999. A protocol for conflict resolution in analyzing empirical data related to natural resource controversies. Wildlife Society Bulletin 27: 1050–1058.

Anthony, R.G.; Forsman, E.D.; Franklin, A.B.; Anderson, D.R.; Burnham, K.P.; White, G.C.; Schwarz, C.J.; Nichols, J.; Hines, J.; Olson, G.S.; Ackers, S.H.; Andrews, S.; Biswell, B.L.; Carlson, P.C.; Diller, L.V.; Dugger, K.M.; Fehring, K.E.; Fleming, T.L.; Gerhardt, R.P.; Gremel, S.A.; Gutierrez, R.J.; Happe, P.J.; Herter, D.R.; Higley, J.M.: Horn, R.B.; Irwin, L.L.; Loschl, P.J.; Reid, J.A.; Sovern, S.G. 2004. Status and trends in demography of northern spotted owls, 1985–2003. Final report to the Regional Interagency Executive Committee. On file with: Regional Ecosystem Office, 333 SW First Avenue, Portland, OR 97204.

Burnham, K.P.; Anderson, D.R. 2002. Model selection and multimodel inference: a practical information-theoretical approach. 2nd ed. New York, NY: Springer-Verlag. 488 p.

Forsman, E. 2004. Personal communication. Research wildlife biologist. USDA Forest Service, Pacific Northwest Research Station, 3200 SW Jefferson Way, Corvallis, OR 97331.

Franklin, A.B.; Anderson, D.R.; Forsman, E.D.; Burnham, K.P.; Wagner, F.W. 1996. Methods for collecting and analyzing demographic data on the northern spotted owl. Studies in Avian Biology. 17: 12–20.

Lint, J.; Noon, B.; Anthony, R.; Forsman, E.; Raphael, M.; Collopy, M.; Starkey E. 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.

Nichols, J.D.; Hines, J.E.; Lebreton, J.-D.; Pradel R. 2000. Estimation of contributions to population growth: a reverse-time capture-recapture approach. Ecology. 81: 3362–3376.

Olson, G. 2004. Personal communication. Wildlife biometrician. Nash Hall, Oregon State University, Corvallis, OR 97330.

Pradel, R. 1996. Utilization of capture-mark-recapture for the study of recruitment and population growth rate. Biometrics. 52: 703–709.

Thomas, J. W.; Forsman, E.D.; Lint, J.B.; Meslow, E.C.; Noon, B.R.; Verner, J. 1990. A conservation strategy for the northern spotted owl: a report of the Interagency Scientific Committee to address the conservation of the northern spotted owl. Portland, OR: U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service, National Park Service. 427 p.

U.S Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management [USDA USDI]. 1994. Final supplemental environmental impact statement on management of habitat for late-successional and old-growth forest related species within the range of the northern spotted owl. Volumes 1-2 + Record of Decision.

U.S. Department of the Interior. 1992. Final draft recovery plan for the northern spotted owl. Unpublished report. U.S. Department of the Interior. Washington, D.C. On file with Region 1 office of the U.S. Fish and Wildlife Service, Portland, OR.

White, G.C.; Burnham, K.P. 1999. Program MARK: survival estimation from populations of marked animals. Bird Study. 46: 120–138.

White, G.C.; Burnham, K.P.; Anderson, D.R. 2001. Advanced features of Program Mark. In: Field, R.; Warren, R.J.; Okarma, H.; Sievert, P.R., eds. Wildlife, land, and people: priorities for the 21st century. Proceedings of the Second International Wildlife Management Congress. Bethesda, MD: The Wildlife Society: 368–377.

Frank Oliver