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HISTORY OF DEMOGRAPHIC STUDIES IN THE MANAGEMENT OF THE NORTHERN SPOTTED OWL

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INTRODUCTION

The natural history of the Northern Spotted Owl (*Strix occidentalis caurina*) has been well documented because of its association with late seral stage forests in the Pacific Northwest (Gutiérrez et al. 1995). Conservation of the Northern Spotted Owl has been an extremely contentious issue among environmentalists, timber industry groups, land managers, wildlife managers, and scientists because of the great economic value of the trees within its habitat (Forsman and Meslow 1986, Simberloff 1987, Thomas et al. 1990, Thomas et al. 1993a,b, USDI 1992b, Harrison et al. 1993). The controversy began in the early 1970's shortly after the first comprehensive studies of the owl were initiated in Oregon and California (Forsman 1976, Gould 1977). Initially, the primary concern was that logging of mature and old-growth forests was a serious threat to the owl (USDI 1973, Forsman 1976). Harvest of old-growth forests continued on federal lands in the Pacific Northwest at high levels during the 1970's and 1980's despite growing environmental conflict. As the owl's habitat gradually declined, management options decreased, litigation increased, and a plethora of committees, task forces, and work groups attempted to find biologically and socially acceptable solutions to the dilemma (Meslow 1993). The situation became especially acrimonious in 1989, when a series of lawsuits filed by environmental groups essentially halted the sale or harvest of old forests on federal lands within the range of the Northern Spotted Owl (e.g., Seattle Audubon vs Evans 1989, Portland Audubon vs Lujan 1987, Lane County Audubon Society vs Jamison 1991).

The Northern Spotted Owl was federally listed as threatened in 1990 on the basis of three findings by the U.S. Fish and Wildlife Service (USDI 1990): (1) suitable forest habitat was declining throughout its range, (2) populations showed declining trends, and (3) existing regulatory mechanisms were not adequate to protect the owl. Listing of the owl was a particularly sensitive issue because protection measures for federally listed species apply to all lands, regardless of ownership.

In response to the need for owl management strategies, wildlife scientists have made extensive use of empirical data from mark-recapture and telemetry studies to estimate vital rates of Spotted Owls (e.g., Thomas et al. 1990, USDI 1990, Anderson and Burnham 1992). These studies have been used to evaluate population trends and to parameterize theoretical population models that have been used to compare the relative performance of different management strategies. Therefore, we have two objectives in this chapter. First, we provide a synopsis of the influence of these studies on the evolution of owl and forest management plans in the Pacific Northwest to provide context to the demographic studies in the following chapters. Second, we provide a brief review of some of the recent landmark events in the conservation of the owl.

HISTORICAL ROLE OF DEMOGRAPHY IN SPOTTED OWL CONSERVATION

Early conservation efforts for the Northern Spotted Owl were justified primarily on the basis of the strong association between the owl and old forests, and on data suggesting a decline in numbers of sites occupied by owls, concurrent with harvest of old forests (e.g., Forsman et al. 1984). However, during the last decade, the focus of research has shifted from estimating owl numbers and densities to estimating trends in reproduction and survival. This shift in emphasis was appropriate because the link between habitat loss and population trends based on fitness criteria (e.g., survival and reproduction) was considered a more reliable measure of population performance (see Van Horne 1983).

The Northern Spotted Owl issue has been unique among endangered species conservation problems because scientists and wildlife managers knew after almost two decades of research that a relatively large population of Spotted Owls existed in the wild and that, although considerably reduced, the habitat of the owl was still relatively widespread. Thus, the primary questions that scientists were asked to address were "how many Spotted Owls are needed to maintain viable populations?" and "are Spotted Owls really declining as a result of habitat loss?" Answers to these questions required a thorough understanding of owl population dynamics (Dawson et al. 1987).

To provide information on population vital rates, a series of five independent, but closely

coordinated, demographic studies were initiated within the range of the owl between 1985–1987 (Anderson and Burnham 1992). Investigators collaborated to ensure that data were collected consistently, with the proximal intention of estimating trends in populations and the ultimate goal of developing a better understanding of factors regulating and affecting Spotted Owl populations. Therefore, the emphasis in these studies was on the demographic processes (especially birth and death rates).

Consistency among the studies was achieved by the shared development of techniques and protocols by researchers for surveys, banding, and determination of reproductive success (see Forsman 1983, Franklin et al. *this volume*). The ability to achieve consistency was due, in part, to the traits of the owl (e. g., territorial, site tenacious, and responsive to imitated vocalizations). Because all researchers whose papers compose this compendium used similar techniques and protocols, results from different studies allowed the use of statistically powerful meta-analyses (Fernandez-Duque and Valeggia 1994) to examine range-wide trends in population parameters (Anderson and Burnham 1992, Burnham et al. 1994b).

In addition to the five original demographic studies, at least ten additional demographic studies of Spotted Owls were initiated between 1989–1992. The 11 studies represented in the following chapters occurred in most of the physiographic provinces within the range of the owl (Figure 1). Between 1983–1993, researchers on the various study areas banded over 7,000 Northern Spotted Owls. Collectively, these studies constitute the largest detailed population dynamics study based on mark-recapture methods of a predatory bird ever conducted.

The Spotted Owl controversy has resulted in a proliferation of mathematical population models designed to investigate the hypothetical responses of owl populations to different kinds of landscape management. Lande (1987, 1988) first explored extinction theory relative to Spotted Owls. Noon and Biles (1990) then used models to examine the sensitivity of the finite rate of population change to estimated vital rates. Territory cluster models, spatially explicit population models, and dispersal models also have been developed to explore conservation strategies for Spotted Owls (e.g., Thomas et al. 1990, Lamberson et al. 1992, Carroll and Lamberson 1993, McKelvey et al. 1993, Boyce et al. 1994, Raphael et al. 1994, Bart 1995).

We emphasize that population models and theory have been used primarily to examine hypothetical population performance under different sets of assumptions about landscapes and behavior. They cannot be regarded as definitive analyses of population processes or performance. Nevertheless, demographic information and population models have become "weapons of choice" among competing advocacy groups (see below). The distinction between population modeling and population analysis is blurred in the mind of the public. The first is an abstraction and the latter is an objective assessment of empirical data. Population models are constructed by depicting, mathematically, the characteristics of a population and then examining the hypothetical population behavior under a variety of

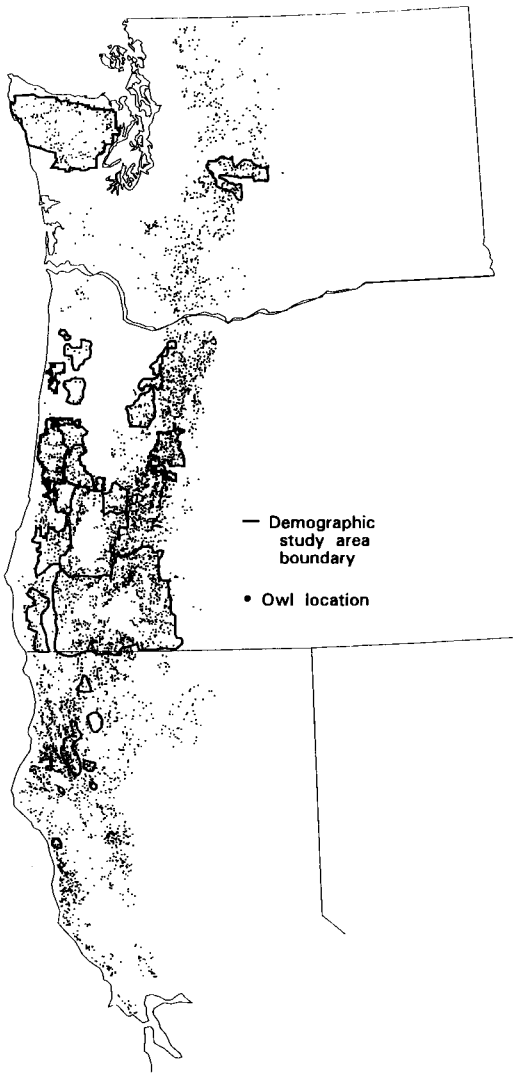

FIGURE 1. Location of known territorial Spotted Owl pairs, single owls, and demographic study areas in the Pacific Northwest.

assumptions. They can be simple or complex depending on the number of parameters used and their purpose. Models can be constructed without knowledge or estimates of the actual parameter values. That is, one can guess at the value or limit of specific parameters. Therefore, population models can be far from reality if the parameters used to qualify the model are incorrect. On the other hand, population analyses, such as those represented by the following chapters, are based on objective evaluation of the life history information of the bird derived by capturing, marking, and resighting the same birds over long periods of time. It is the latter scientific process that currently drives inferences about the status of the Northern Spotted Owl, and is the subject of the chapters in this volume.

USE OF DEMOGRAPHIC DATA IN MANAGEMENT PLANS

The 1988 Final Environmental Impact Statement for the Northwest Region of the U.S. Forest Service

The first attempt to use demographic information for management was a truncated life table analysis based on preliminary estimates of vital rates derived from mark-recapture studies of banded owls and telemetry studies of juvenile owls (USDA 1988). The risk of population decline was evaluated under a set of alternative management strategies. The efficacy of the proposed management strategy (a series of widely spaced 400-ha habitat islands managed for individual owl pairs) was considered poor based on this analysis. Litigation (Seattle Audubon vs Evans 1989) forced abandonment of this management strategy primarily because the demographic analysis indicated a poor long-term prognosis for the owl population.

The Interagency Scientific Committee (ISC)

In 1989 a group of scientists was selected by the affected Federal agencies charged with managing Spotted Owls to develop a scientifically credible conservation plan for Northern Spotted Owls on federal lands (Thomas et al. 1990). This team initially addressed the problem by asking four questions, two of which were related to demography: (1) are Spotted Owl populations declining?, and (2) are there gaps in the distribution of owls resulting from human-caused factors? The ISC concluded that the answer to these questions was "yes." The ISC proposed a conservation strategy that included a system of relatively large habitat conservation areas distributed across the range of the owl. Demographic information was used to estimate theoretically the minimum size of reserves necessary to maintain short-term (<100 years) population stability as well as to evaluate scenarios of range-wide distributions of owls. Although criticized as inadequate by some scientists and environmental groups (e.g., Harrison et al. 1993), the conservation strategy proposed by the ISC served as the model for a series of subsequent owl and old-growth forest conservation plans. The USDA Forest Service issued a directive to manage in a manner "not inconsistent with" the ISC plan, but litigation forced the agency to broaden the management plan to include all late-successional forest species as well (Seattle Audubon Society vs. Mosley civil case No. C92–479WD).

The Northern Spotted Owl Listing Decision

A petition to list the Northern Spotted Owl under the Endangered Species Act was filed with the U.S. Fish and Wildlife Service in 1987. The U.S. Fish and Wildlife Service completed a status review in December 1987 and concluded that listing was not warranted. This decision was challenged in U.S. District Court in 1988 (Northern Spotted Owl and Seattle Audubon Society vs. Hodel, civil case No. C88–573Z). The court ruled that the decision to not list the owl was arbitrary and capricious, and instructed the Service to reexamine the issue (see GAO 1989 for a review). Following a review of the evidence by another status review team and a listing review team (Anderson et al. 1990), the Northern Spotted Owl was listed as "threatened" in 1990 (USDI 1990). Habitat loss, apparent population declines, and failure of existing regulatory mechanisms to protect the owl were the primary reasons cited for listing. Information gathered from demographic studies was used extensively by the teams to evaluate the population status of the owl.

Scientific Panel on Late-Successional Forest Ecosystems Report to the U.S. House of Representatives

In 1991, following a request from two committees in the House of Representatives, a team of four scientists was formed to develop a series of alternative strategies for the management of mature and old-growth forests in the Pacific Northwest (Johnson et al. 1991). This team developed 14 different alternatives for the management of old forests, 12 of which were based on a network of large reserves similar to the reserve design proposed by the ISC for Spotted Owls. The size and spacing of the proposed reserves were heavily influenced by the analyses of owl demography conducted by the ISC, and by consideration for Marbled Murrelets (*Brachyramphus marmoratum*) and fish. None of the op-

tions proposed by the panel was ever officially adopted. However, these options played a major role in subsequent plans for owls and old forests.

The Northern Spotted Owl Recovery Plan

A Northern Spotted Owl recovery team was formed in 1990. The team was unique among recovery teams because it was appointed by the Secretary of Interior and the majority of the team members were non-scientists (Gutiérrez 1994b). The recovery team used the ISC reserve design as a working model for the design proposed in the recovery plan. However, the recovery team departed from the standard format of identifying numerical targets as de-listing criteria. Rather, the de-listing criteria were based on trends in demographic rates within specific physiographic provinces (USDI 1992b). In other words, population processes were emphasized rather than simple numbers. This departure from tradition was necessary because (1) Spotted Owls were still relatively numerous in most provinces, (2) census information was incomplete, and likely to remain so, (3) logging was still allowed under the plan, and (4) the existing demography studies demonstrated that owl trends could be monitored.

Anderson and Burnham (1992) analyzed the extant demographic data for the recovery team. Their results indicated that Spotted Owl adult female mortality was accelerating over the period during which the demography studies occurred. This result directly led a Federal Court judge to reject the 1992 U.S. Forest Service Spotted Owl EIS.

The Recovery Plan, like the ISC plan, assumed that owl populations would reach a new lower carrying capacity where they would eventually stabilize. Thus, it was likely that owl numbers would continue to decline in the near term or until habitat recovery within designated conservation areas balanced loss of habitat outside of conservation areas. The recovery plan was completed in 1992 but was never formally released by the USDI.

The Endangered Species Committee

During the recovery planning process, the Director of the Bureau of Land Management (BLM) requested that a cabinet-level committee be convened to determine the fate of 44 proposed timber sales on BLM lands in western Oregon that had been found by the U.S. Fish and Wildlife Service to "jeopardize" the Northern Spotted Owl. After an evidentiary hearing in January 1992 before an administrative law judge, the committee acted to protect all but 13 of the sales from logging. The primary reasons for the continued protection was the potential negative demographic consequences to the owl population. Of particular concern was the potential loss of habitat connectivity between physiographic provinces. The demographic information derived from the population studies was key to the discussion of possible demographic consequences of the proposed logging. The 13 sales were subsequently withdrawn from logging by the BLM.

The Scientific Analysis Team (SAT)

In response to instructions from a federal court judge, the Chief of the Forest Service convened a panel of scientists to assess the viability of species associated with old forests on Forest Service lands within the range of the Northern Spotted Owl. This was the first time that the Forest Service had formally attempted to evaluate proposed plans for the Spotted Owl in a broader ecosystem context. After examining the demographic data on the Spotted Owl, the SAT concluded that ". . . demographic rates or trends observed during a prolonged period of habitat loss will provide little insight as to whether the population will eventually reach a new stable equilibrium when the rate of habitat loss is equaled by the rate of habitat gain . . ." (Thomas et al. 1993a:192). This opinion was in stark contrast to the opinions of some other scientists and environmental advocates who had suggested that the negative trends in demographic data were evidence that proposed agency plans for the owl were inadequate (e.g., Harrison et al. 1993).

The Forest Ecosystem Management Assessment Team (FEMAT)

In 1993, the Clinton Administration initiated an effort to resolve the Spotted Owl/old-growth forest impasse by appointing a team of scientists to develop a comprehensive plan for the management of late successional forests on federal lands in the Pacific Northwest (Thomas et al. 1993b). The ten management options proposed by the FEMAT included provisions for various levels of protection for Spotted Owls as well as other late seral stage forest species. The option selected by the Administration (referred to as "Option 9") was similar to several previous plans (Thomas et al. 1990, Johnson et al. 1991, USDI 1992b), with some modifications in reserve design and major changes in recommendations for management of forest lands between the reserve network. Although FEMAT discussed demographic data from capture-recapture studies in their analysis, they concluded that current demographic data alone were not appropriate to assess the outcome of a management plan that would not produce the desired mix of habitats until approximately 100 years after implemen-

tation. After release of the FEMAT report, some scientists and environmental activists suggested that the negative trends in population parameters reported by Anderson and Burnham (1992) were sufficient to warrant an immediate cessation of all logging of owl habitat (e.g., Harrison et al. 1993). This view was supported by a group of 14 scientists who wrote a letter to the Secretaries of Interior and Agriculture in September 1993, requesting that implementation of Option 9 be delayed until a full review of all existing demographic information on the Northern Spotted Owl was conducted.

The 1993 Fort Collins Workshop

Several industry groups and timber companies began population studies of Spotted Owls in 1990–1991. These studies paralleled other studies on Federal lands, and resulted in relatively large numbers of owls being located and banded in young and mid-aged (40–70 years) forests in some areas (most notably northwestern California and the east slope of the Cascades in Washington). These findings were interpreted by some as an indication that Spotted Owls were thriving in young forests (e.g., Easterbrook 1994), and motivated a de-listing petition for Spotted Owls in California (California Forestry Association 1993). As a result of this de-listing petition and the previously mentioned September 1993 letter from a group of concerned scientists, the Secretaries of Interior and Agriculture requested in October 1993 that a workshop be immediately convened to update and analyze all demographic data on the Northern Spotted Owl.

All researchers having three or more years of demographic information were invited to attend. Eleven research groups participated. One industry group participated initially, but withdrew their results before the end of the workshop. Two other invited industry groups did not present their data for analysis. The results of the analyses conducted at Fort Collins were provided to the U.S. Forest Service and Bureau of Land Management for inclusion in their planning documents. The results of the individual study area analyses and the meta-analysis of the entire data set form the basis for the individual chapters that follow this review.

The 1994 U.S. Forest Service and BLM Final Supplemental Environmental Impact Statement (FEIS)

In February 1994, the USDA Forest Service, USDI Bureau of Land Management, and several other federal agencies released a joint FEIS for the management of late successional forests within the range of the Northern Spotted Owl (USDA and USDI 1994a). A formal presentation of the summary data from the Fort Collins demographic workshop was included in the FEIS (Burnham et al. 1994b). The Record of Decision for the FEIS (USDA and USDI 1994b) was to proceed with implementation of Option 9 (now Alternative 9) on Federal lands, with some adjustments to improve dispersal habitat and to protect additional pairs of owls in some provinces. Despite the negative population trends estimated from the demographic data examined at Fort Collins, it was the opinion of the FEIS Team that the owl population would likely reach equilibrium once the habitat conditions specified in Alternative 9 were attained. A spatially explicit population model (McKelvey et al. 1993), parameterized with demographic data, was used to evaluate the performance of the preferred alternative assuming a range of birth and death rates.

Adversarial Proceedings

Demographic information and estimates of habitat loss have been central to litigation and procedural arguments levied by competing advocacy groups (i.e., environmental and industry groups). Demographic trends have been a critical element in this process. Some scientists and environmental activists have relied on demographic trend information and estimates of vital rates derived from demographic studies to suggest that proposed plans do not adequately protect the Spotted Owl (e.g., Harrison et al. 1993, Lande et al. 1994). Other scientists and industry advocates have countered by suggesting that the demographic data may be flawed or that models used to analyze the data may be overly simplistic or inappropriate (e.g., Boyce 1987, Boyce et al. 1994, Bart 1995). In addition, some have tended to emphasize the results of models on demographic processes (e.g., Lande et al. 1994), whereas other groups have emphasized the relatively large size of the owl population (e.g., California Forestry Association 1993). Some scientists associated with the demographic studies of Spotted Owls have assumed a more cautious position, suggesting that there is uncertainty regarding interpretation of the data, and that all of the protagonists should avoid extreme positions (e.g., Thomas et al. 1993a, USDA and USDI 1994a).

SUMMARY

Management of the Northern Spotted Owl is an extremely contentious conservation issue involving many interest groups with divergent views about how the needs of the owl and society should be balanced. It has become a biopolitical cornerstone of large scale conservation policy. Wildlife scientists have played a key role in the development of conservation strategies for the

owl and have made extensive use of empirical data from mark-recapture studies for assessing trends in vital rates and for parameterizing theoretical population models. Demographic information, gathered from a series of studies across the range of the owl represents the most detailed population dynamics study of a predatory bird ever undertaken. This information has been used in unique ways and has strongly influenced the conservation of the owl and its habitat. The Spotted Owl issue is unique among endangered species problems because owls were widespread and relatively common over much of their range when demographic studies began. The assessment of birth and death rates to estimate population trends was necessary because estimating changes in owl habitat, or in overall numbers of owls, were insufficient tools to adequately assess population trends. In essence, biologists were asked not only to estimate the status of different owl populations but also to estimate how much logging could continue while local populations declined. Because the owl primarily inhabits old-growth and mature forests on public lands, declining populations have resulted in substantial restrictions in logging on public lands. Decisions to restrict harvest have been considerably influenced by demographic studies of Spotted Owls conducted between 1985–1993. We present a brief history of the role of demographic data in the development of management strategies for the owl.

In addition to the utility of demographic information for the solution of a resource problem, these studies have stimulated theoretical work in such areas as extinction thresholds, population dynamics, dispersal, and reserve design (Lande 1987, 1988; Doak 1989; Thomas et al. 1990; Franklin 1992; Lamberson et al. 1992, 1994). Thus, the demographic studies in the following chapters serve as an example of the effectiveness of coordinated research to problem solving and the advancement of science.

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