Chapter 12

Information Needs: Boreal Owls

Gregory D. Hayward, USDA Forest Service,
Rocky Mountain Forest and Range Experiment Station, Laramie, WY 82070

INTRODUCTION

Most humans are reluctant to make decisions without thorough knowledge of the consequences of those decisions. Therefore, a desire for further research is almost universal in any complex management arena. The value of further study is determined, in part, by the cost in time and resources to obtain new information and the cost of making incorrect decisions without the desired knowledge. In the case of managing forest lands and conserving boreal owls, our knowledge is so limited that well directed research on distribution, habitat use at many scales linked with studies of local demography, forest history, and interactions with competitors and predators can further our understanding at little expense compared to the potential benefits of managing forests without adverse effects on boreal owls and the larger subalpine ecosystem.

In this chapter, I will assess the strength of existing knowledge in forming a conservation strategy. Then I will discuss some strategies for obtaining needed information. This chapter will include few citations because it relies on Chapters 9 and 10 which review literature on this species and some of the forests it inhabits.

STRENGTH OF EXISTING KNOWLEDGE TO FORMULATE A CONSERVATION STRATEGY

Throughout this section I approached each topic as a question. Is our understanding of this topic sufficient to support the development of a sound, national-scale conservation strategy for the boreal owl? For example, "is the response of boreal owls to stand level habitat change understood in sufficient detail to formulate a conservation strategy?"

Distribution

Current knowledge of boreal owl distribution is not sufficient to support the development of conservation strategies. In the western United States (excluding Alaska), our knowledge is sufficient to predict, on a broad scale, where boreal owls are likely to occur and thereby indicate to land managers where management of the species should be a concern (see Map 2). In Alaska and east of the Rocky Mountains, particularly in the Great Lakes region and New England, understanding of the species distributional status is very weak. Knowledge of distribution is growing rapidly, however, and land management agencies have the capability to obtain the necessary information in several years. Methods for determining boreal owl distribution (not abundance) using playback surveys have been developed and are being used by managers.

Response of Boreal Owls to Stand-Level Habitat Changes

Current knowledge indicates that boreal owls in some geographic areas use mature and older forest habitats for critical life functions. Land managers, however, must predict the response of particular boreal owl populations to various management actions in order to assess the consequences of alternatives. Our knowledge is not sufficient to complete this task.

Our understanding of habitat use by boreal owls does not allow a ranking of habitats in terms of quality. Knowledge of habitat use based solely upon observations of habitat use will not be sufficient to guide habitat management. Rather, the relative productivity of owl populations among different habitats must be discerned in order to provide a ranking system with which to weigh alternative land management schemes.

Even habitat use data are unavailable for most geographic areas within the species' range. Geographic variation in habitat quality must be documented and developed into a ranking among habitats. Furthermore, proximate and ultimate factors determining the observed pattern of owl success among habitats must be understood in order to predict habitat use patterns for locales other than those studied. In other words, the relationship between the owl and its prey, primary cavity nesters, potential predators, and competitors and habitat relationships of each must be addressed to formulate a predictive model useful in evaluating management alternatives.

Effects of Landscape-Scale Changes on Home Range Use

Boreal owl studies have not examined the influence of habitat characteristics at the landscape scale on home range size or the success of individuals. The literature demonstrates that under some circumstances boreal owls occupy home ranges that exceed 2,000 ha and therefore indicates that management for boreal owls must consider extensive landscapes. The available studies do not aid managers in evaluating different mixes of forest age classes or provide a sound basis for predicting local or regional variation in home range use.

Effects of Regional-Scale Habitat Changes on Movement Patterns

Annual and seasonal movement patterns of boreal owls in North America are virtually unknown. Without this knowledge the demographic interactions among populations forming the larger metapopulation cannot be discerned. Therefore, the regional effects of local management actions cannot be addressed. For example, current knowledge of owl movements is not sufficient to determine whether management in montane forests below the subalpine zone will influence movements between populations.

Effects of Stand-Level Habitat Changes on Foraging Behavior

Boreal owl foraging behavior and habitat use is very poorly understood. For instance, the response of foraging owls to landscape boundaries (meadow or clearcut edges, changes in tree density) have not been observed. The interaction between prey abundance and habitat structure in determining prey availability is also poorly understood. The importance of understanding the foraging ecology of boreal owls cannot be over emphasized. Studies in Europe and North America indicate populations are frequently food limited. Prey abundance and foraging habitat condition together determine population trend for many populations.

Understanding how owl movements change when individuals encounter landscape boundaries of different types and the role of corridors in dispersal will facilitate building models to predict the impact of different harvest prescriptions on foraging success. Coordinated investigations examining the relationship between habitat condition and prey abundance would increase the predictive power of such a model.

Demography

Knowledge of boreal owl demography is not sufficient to estimate persistence of either local populations or metapopulations. Reproductive rates of boreal owls and the factors determining productivity are documented for populations in Europe, and productivity has been observed for several populations in North America. Age-specific survival and factors influencing survival are virtually unknown. Likewise, age-specific dispersal and the factors influencing immigration and emigration are not understood. The interaction between environmental conditions (forest structure, prey populations, predators, competitors, landscape patterns) and demographic parameters must be understood prior to developing comprehensive management plans for boreal owls. This does not mean that management is not possible without data on the demography of every target population. Rather, patterns of change in demography across the species' range should be understood so that a reductionist approach to management is unnecessary.

Methods to monitor the trend of boreal owls in selected populations will be necessary to evaluate management practices and facilitate adaptive management responses. Development of methods other than playback surveys has begun (Hayward *et al.* 1992) but these methods must be validated and refined if they are to be used effectively by management.

Dynamics of Primary Plant Communities

Knowledge of the successional dynamics of subalpine and boreal forests, while not complete, is extensive and will facilitate prediction of future forest conditions, particularly as that knowledge relates to the dominant tree species. Forest ecologists understand many of the factors related to the occurrence of major natural disturbance agents (fire, insects, windfall, and disease). Factors influencing seed crops, regeneration and survival of trees, gap dynamics, and material cycling have been studied. The stochastic nature of disturbance agents have been incorporated into conceptual models of forest dynamics at the stand and landscape scale.

Understanding of the dynamics of forest species other than the dominant tree species is less complete. The seral development of the detritus system, so important to subalpine forests, is not understood. Similarly, the dynamics of fungi and lichen populations that are important to small mammals have received little attention. Knowledge of understory-plant population dynamics is incomplete. These areas of forest ecology need further attention in order to understand the dynamics of small mammal populations.

The population dynamics (production, survival) of tree cavities used by boreal owls is also poorly understood. Biologists do not understand the characteristics of forest stands (other than tree size and presence of primary cavity excavators) that determine the production of tree cavities. The role of tree disease (fungi, insects), wind damage, and moisture conditions in cavity production are not understood. Likewise, what factors determine the lifespan of tree cavities has received limited attention.

History of Distribution and Composition of Forest Communities

Forest ecology has recently directed more attention toward the historical ecology of forests. Despite these efforts, synthesis of data on the historic abundance and distribution of subalpine and boreal forests is not sufficient to indicate how current trends compare to the past. In particular, knowledge of patterns in distribution and abundance of older age classes of these forests has not been synthesized.

To aid in conservation planning for boreal owls, historic ecology must include investigations examining patterns in these forests thousands of years ago as well as in recent centuries. The value of the historic information lies in the perspective it can provide on the potential variation in boreal owl distribution in the past and therefore the range of conditions that the species faced.

A RESEARCH DIRECTION

The assessment of current knowledge points to major topics that must be addressed in future research designed to provide the basis for a conservation strategy. I will not set priorities among these themes because many of the topics are parallel. For instance, knowledge necessary to rank habitat quality will not improve habitat management without knowledge of forest dynamics. Instead, in the section that follows, I provide direction in research philosophy and ideas for research approaches. My goal is to outline the scope of investigative approaches that will be necessary to obtain the knowledge highlighted above.

Integrate a Variety of Research Tools

A research program designed to obtain the knowledge necessary to build a conservation strategy for boreal owls will require the integration of several research approaches. Modeling, field experiments, and observational studies must be integrated so the knowledge stemming from each approach contributes toward corroborating or refuting key hypotheses. It will be necessary to coordinate efforts using each of these tools in several strategically selected geographic locales in order to elucidate the ecology of boreal owls in particular environmental settings and describe how the species' ecology varies across environmental gradients. In addition to employing a range of research approaches, studies must be carried out across a range of spatial scales. Below I will describe how I envision the employment of these research tools to obtain the information necessary to manage boreal owls over a broad geographic area.

Modeling

Boreal Owls in the Subalpine Forest.—The biological and ecological topics identified in the first portion of this chapter represent interesting research topics on their own but become significant when integrated as a body of knowledge to understand the subalpine forest system in which the boreal owl exists. The envirogram depicted in figure 5, Chapter 9 represents a hypothesis of how the components of the subalpine forest relate to the ecology of boreal owls. This envirogram should be elaborated into a model describing the processes that link the boreal owl to other components of the subalpine forest system. The model should predict how changes in subalpine forests (e.g., biomass of logs, abundance of woodpeckers, or size class distribution of trees) would impact boreal owl populations. Such a model would begin as a qualitative representation of the system generating specific hypotheses that could be tested through field research. As particular linkages are examined, portions of the model should be refined into quantitative expressions of the system. Without such a predictive model, research at the stand and watershed scales will lack focus and likely not concentrate on key characteristics of the owl/forest system. A well developed and tested model would ultimately provide managers with a tool to evaluate the consequences of management on the boreal owl through the impacts on the forest system.

Individual-Population Demographic Models.—Although reliable estimates of mortality rates, immigration rates, and emigration rates are not available, preliminary modeling of boreal owl demography will be useful in focusing research and refining the assessment of conservation status. Preliminary estimates of demographic parameters (which are available — see Chapter 9) would permit examination of life history sensitivities. Based on these analyses, and refinements of the models as more precise demographic data are gathered, managers will become aware of aspects of the owl's life history that are more sensitive to change. Through use of these demographic models, assessments of persistence probabilities will be refined and management alternatives more easily compared.

Examination of individual-population demographic models would aid in understanding the relative quality of different habitats for boreal owls. Habitat quality is most directly expressed through population trend (quality habitat leading to $\lambda > 1$). Through the joint examination of local demography and habitat characteristics, poor and good quality habitat may be identified, providing important information for managers (see Small Scale Demography below).

Spatially Explicit Metapopulation Models.—Based on the distribution and life history of boreal owls, Hayward *et al.* (1993) hypothesized that boreal owls occur in the United States as a strongly structured metapopulation. This hypothesis must be tested using observational field studies documenting the degree of demographic linkage among boreal owls occupying separate patches of habitat. Based on this hypothesis, a metapopulation model for the Rocky Mountains, Blue Mountains, and Northern Cascades should be built. This model would integrate with field studies on boreal owl dispersal, local demography, and habitat use in an interactive sense. Field results would be used to parameterize the model while the model would be employed to focus field studies geographically and toward particular questions. The model would be tested and refined as field data accumulated.

The Geographic Information Systems (GIS) data base necessary to develop such a model would be expensive and time consuming to develop. However, the U.S. Fish and Wildlife Service's Gap Analysis program could provide the necessary data at the proper scale. Using the vegetation and topographic layers built into the Gap data bases, the predicted distribution of boreal owl populations would be estimated based on a series of geographically tuned owl habitat models.

The metapopulation model would be a valuable tool for management and research. Managers could immediately employ the geographic data in biological evaluations or other impact assessments. They could also use the model to predict the location of unidentified owl populations and test those predictions through surveys. Research would use the model to aid in setting priorities among research topics based on a sensitivity analysis. The model could also aid in choosing study areas based on which owl populations are predicted to be key populations for the persistence of boreal owls.

Experimental Studies Using Management Treatments

Experimentation is the workhorse of modern science. Experiments provide the most straight-forward methods to examine cause-and-effect and to determine the processes responsible for patterns observed in natural history investigations. Unfortunately, ecological experiments employing appropriate sampling designs and proper controls are difficult to design and execute (Hairston 1989), especially in studies of large, low density, mobile vertebrates. Coordinated efforts between management and research can overcome some of the logistic difficulties in producing large scale treatments and measuring the effects.

Experiments will be necessary to determine the response of major prey populations to various timber harvest techniques and to rank the quality of owl habitats. Some of these experiments will require landscape scale treatments that are routinely carried out by management. In order to use timber sales as treatments, however, researchers must determine (using a well defined sampling protocol) how treatments are assigned to experimental units (stands or larger land units) and what treatments will be employed.

The link between arboreal lichen and boreal owls depicted in the Envirogram (figure 5, Chapter 9) provides an example of the power of experimentation in developing knowledge necessary to manage boreal owls. The envirogram leads to the hypothesis that red-backed voles (a major winter and summer prey of boreal owls) will be more abundant in forests with greater biomass of *Bryoria sp.* and related lichen. This hypothesis can be tested through a series of laboratory (feeding trial) and field (lichen removal and addition) experiments.

As demonstrated by Korpimaki (1988, 1989), nest boxes can be employed to facilitate experiments with boreal owls. Hayward *et al.* (1993) employed nest boxes in a small experiment examining the relative importance of forest structure vs. cavity availability in nest site selection by boreal owls. Linkages between habitat structure and nesting of boreal owls should be further explored through nest box experiments.

Observational Studies

Many of the gaps in our knowledge cannot be filled through experimental investigation. The historical ecology of forests used by boreal owls will be learned through careful "sleuthing." Hypotheses may be posed and observations (pollen sediment patterns, etc.) used to determine the legitimacy of those hypotheses. Similarly, dispersal patterns of boreal owls will be learned through "simple" observation. Studies of dispersal must discern how dispersing birds react to edges, what habitats they will fly across, etc. Observational studies will also be essential in providing parameter estimates for modeling efforts at many scales and in forming hypothesis to be tested through experimentation. As a consequence of the large home ranges of individual boreal owls, and because of the difficulties encountered in large scale experiments, most field research on boreal owls will involve observational investigations.

Beyond Tools

Examine Boreal Owl Ecology at a Range of Scales

As indicated earlier, a sound conservation strategy will require understanding the response of boreal owls to habitat change on a range of geographic and temporal scales. Research approaches must differ across scales involving different mixes of modeling, experimentation, and observational studies. Studies that examine hypotheses stemming from models built from an expansion of the envirogram presented in Chapter 9 will largely focus on ecological patterns and processes at relatively fine scales (forest stands and small watersheds encompassing one to several square km). At this scale, some experimentation will be possible.

At a broader geographic scale, the response of boreal owls (home range characteristics, population density, productivity, movements) to landscape patterns must be examined. Individual-population dynamics models that examine the sensitivity of various life history characteristics will help focus this research. Gathering the population and behavior data necessary to answer questions at this scale will require an extensive system of nest boxes facilitating studies in a range of geographic settings. Hayward *et al.* (1992) describe such a system that is similar to the programs established by successful scientists in Europe (e.g., Korpimaki 1981, Sonerud 1985).

Research at the regional scale will largely involve integrating knowledge obtained at finer scales into metapopulation models and then testing the predictions of those models. Empirical information on dispersal of juvenile and adult boreal owls will be critical to developing any metapopulation model. Exercising the metapopulation models to predict future conditions for boreal owls will require sound, spatially specific information from land management plans. Development of sound metapopulation models that examine patterns of boreal owl occurrence over multiple Forest Service Regions will be critical in coordinating management and determining broad research priorities.

Investigate Geographic Variation

Understanding patterns of variation in boreal owl habitat use, demography, population regulation, movement patterns, and food habits will produce many of the insights necessary to manage the species. In European boreal owls, productivity and movements vary geographically. This variation has led to interesting hypotheses concerning the role of various biotic and abiotic factors in boreal owl life history.

Investigate Many Questions on the Same Site

A complex web of interactions is described in the ecological web depicted in figure 5, Chapter 9. Understanding this web will require the integration of studies involving many disciplines — plant ecology, fire ecology, mycology, mammalogy, and community ecology to name just a few. Focusing investigations from many disciplines on common sites will facilitate understanding of the links in this web. These studies should be developed using techniques and approaches employed in population and community ecology.

For example, population and community level investigations of small mammals should be conducted on the same sites as studies of owls. An understanding of small mammal population dynamics and habitat selection will require information on forest structure and dynamics including understory vegetation, fungi, and lichen. The necessary coordination among disciplines is obvious.

Coordinating interdisciplinary research is not trivial, however. Much has been written about the value of interdisciplinary studies but far less published resulting from such work. Initiating coordinated investigations to understand boreal owl ecology may not be easy. By initiating some studies at existing, long-term ecological research sites, some of the logistic problems could be solved.

Small-Scale Demography

Although ignored for a while in applied wildlife research, demographic studies are becoming a cornerstone upon which conservation programs are built (Dennis *et al.* 1991, Verner *et al.* 1992). Examination of population trend and analysis of the sensitivity of λ to variation in survival and reproduction have been the focus of some investigations. In some efforts, estimation of λ for whole populations was sought.

A potentially more efficient approach would estimate demographic characteristics for small groups of individuals and look for patterns relating demography to characteristics of the environment. These investigations could be approached in an observational or experimental framework. In either case, a system of nest boxes as described in Hayward *et al.* (1992) will facilitate obtaining some of the required data. Without nest boxes it will be extremely difficult to obtain a sample of owls sufficient to answer most questions. Of course, nest boxes cannot be used to answer some questions concerning nesting habitat and must be employed judiciously to avoid biasing results. Studies in Europe by Korpimaki (1981), Sonerud (1985), Lofgren *et al.* (1986) and others have demonstrated the power of nest boxes in studying this species.

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