Chapter 7

Information Needs: Flammulated Owls

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INTRODUCTION

Many kinds of basic information are required to devise a comprehensive and well-informed conservation strategy for this species. It is imperative that a unified, centrally directed approach be taken to obtain this information. Central oversight will make the effort more efficient and cost effective.

Here I assess the adequacy of existing knowledge to support the development of a conservation strategy and I point out specific knowledge gaps that need to be filled. I then describe a unified plan of research that would both provide the needed information and initiate a cost effective long-term monitoring system. The cost effectiveness of doing the necessary research now cannot be overemphasized. This species does not appear to be in immediate danger. Very thorough knowledge of virtually all aspects of its biology can be obtained for a fraction of the amount spent in a single year on an endangered species. Other high-interest forest species, as well as certain insect and plant groups, will also benefit from much of the proposed research.

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 flammulated owl? For example, "is the *distribution* of flammulated owls understood in sufficient detail to formulate regional conservation strategies?"

Distribution

Although systematic distributional surveys have not been conducted, enough has been learned from spotted owl surveys and other sources to delineate the range of the flammulated owl with reasonable confidence. The species is now presumed to occur in all mid-elevation pine forests west of the Black Hills, as well as in a few other forest types. The initiation of regional conservation strategies is therefore justified throughout the western United States. Additional surveys are needed in order to delineate the range in the Oregon Cascades, in Washington, parts of Idaho, Montana, Utah, and Wyoming. Finer scale distribution, i.e., presence on individual Forests and Districts, is not as well understood but not necessary for formulating and implementing regional strategies.

Two aspects of distribution must be clarified, however, before regional strategies can be finalized. These are genetic variation and winter range. The distribution of genetic variation is completely undocumented. Modern studies, using molecular techniques, have not been performed, and subspecies described on the basis of coloration and clines in mensural characteristics are arbitrary and unrecognized by leading authorities (e.g., Marshall 1967, Voous 1989). A species-wide molecular survey of genetic variation would clarify the genetic structure of the U. S. populations and might identify the wintering grounds of well-defined northern populations. These winter ranges, which almost certainly lie in Mexico or farther south, must be discovered and their populations monitored. Otherwise, efforts to maintain the species in the United States could be pointless.

Response of Flammulated Owls to Stand-Level Habitat Changes

The virtual restriction of this species to middle elevations of semiarid mountain ranges is well documented, but the reasons for this habitat specificity remain undetermined. A study of flammulated owl thermoregulation, similar to Ligon's (1969) study of the other North American *Otus*, would indicate whether thermoregulatory constraints limit the upper and lower elevational ranges of the species. Moreover, studies of weight maintenance of provisioned captives kept in humidity and temperature regimes similar to those of upper elevation conifer forests would show whether flammulated owls are capable of tolerating higher elevation forests when food supply is adequate. If such physiological constraints are absent then the limitation of flammulated owls to occupied habitats by food availability, competitors, and/or predators must be considered in management plans.

The response of flammulated owls to stand level habitat change is not understood definitively, but plausible hypotheses have been proposed and should be tested. Reynolds and Linkhart (1992) concluded from data gathered in Colorado that old yellow pine forests are preferred over younger stands for nesting territories, which encompass roosting and feeding as well as nesting per se. Assuming that preference for old forest is widespread, two important questions remain unanswered: (1) Do pairs in old forest have higher fitness (i.e., higher intrinsic rates of increase) than those in territories lacking old trees and other features of old forest? (2) Can the beneficial characteristics (e.g., openness, cavity abundance) of old forest be replicated with certain management treatments in younger forests? Answering these questions will require intensive study, including experimental habitat manipulation to determine the criteria by which flammulated owls choose nesting territories. Multilayered open canopies, with some shrub cover for foraging and dense conifer foliage for roosting, along with adequate nest cavities, are hypothesized to be the major requisites. A research program for studying each aspect of this hypothesis is described below.

Relationships with primary cavity nesters, with competitors (especially mammals), with insect prey populations, and with predators have not been studied quantitatively and require documentation. Of special concern is the European starling (*Sturnus vulgaris*), which is still in the process of invading flammulated owl habitat. Starling expulsion of flickers from old cavities (which is conjectured to be common) could actually lead to an increase in the number of flicker cavities, if it did not lead to the extinction of local flicker populations. Successful introduction of nest boxes to managed stands would remove dependency on primary cavity nesters and lessen the likelihood that unenforcability of snag regulations would lead to the loss of nest sites for the flammulated owl. But, if boxes along roads provided an avenue of population expansion for starlings, the boxes could do more harm than good. Which species would win a starling-flammulated owl contest for a cavity is a fact well worth obtaining, especially if nest boxes situated along roads become a major research tool (see below). Van Woudenberg (1992) suggests that boxes may also attract flying-squirrels, which prey on flammulated owls (Cannings and Cannings 1982).

The relationship between flammulated owls and important insect prey populations are not understood. Furthermore, the role of forest structure and composition in determining the abundance and availability of prey is unknown. How these relationships vary geographically must also be understood in order to predict the consequences of stand management on flammulated owl fitness.

The effect of stand level changes on predators, competitors, and prey species is also potentially serious but will be difficult to gauge until the basic habitat relations of these target species are better understood. Correlational studies and modeling should be undertaken to produce first order approximations of the impacts of predators, competitors, and prey on viability of flammulated owl populations.

The fact that so many unknown factors play into the response of the flammulated owl to managed stand level changes argues for caution in implementing management alternatives that move stands away from presettlement physiognomy.

Effects of Broad-Scale Habitat Changes on Movement Patterns

Daily movement patterns appear largely limited to the owls' territories, which implies that changes in habitat on scales broader than forest stands will not affect within-year foraging success. Broad-scale changes may, however, affect within-year nesting success and survival by changing the mix of predators and/or competitors. Because breeding adult flammulated owls make extra-range movements during the nesting season, apparently to assess prospective mates and territories, broad-scale changes could have an impact on future nesting success. Attempting to evaluate these impacts in advance would be highly speculative.

Seasonal movement patterns evidently exist, but little is known of their extent. The phenomenology of natal dispersal of juvenile owls is barely known. Because a few radio-equipped juveniles have disappeared in August, while adults' radios continued to transmit, it may be hypothesized that natal dispersal takes place in late summer. Similar results have been obtained for the closely related eastern screech-owl (Belthoff and Ritchison 1989). These natal dispersal movements may traverse long distances, and hence may expose inexperienced owls to dangers associated with crossing different habitat types, as hypothesized for the northern spotted owl (Gutierrez *et al.* 1985). The nature of such dangers for dispersing juveniles is not known.

All flammulated owls appear to migrate from nesting areas to wintering areas that are probably hundreds of kilometers to the south. The locations of these wintering areas are unknown. No conservation plan will be complete without knowledge of these locations and provision for threats posed by habitat change en route and in the winter quarters.

Relationship Between Foraging Behavior and Prey Abundance

The relationship between foraging behavior and stand structure has been described, but the relationship between variation in stand structure and foraging success has not been evaluated. Stand level change may affect foraging success by requiring owls to make less efficient maneuvers, which can have a large cumulative effect in a species that must capture many small prey items. Stand level change can also affect the prey base. Flammulated owls appear capable of using a wide variety of prey taxa, but the impacts of switching to alternative prey on reproductive success and adult survival have not been studied. Nor is it known if prey selection is as plastic and opportunistic as it appears. The documented regional variation in prey selection may represent local adaptation (i.e., evolved preferences) rather than opportunistic use of the locally most abundant members of a large prey pool. The impact of stand level habitat change on foraging success and nesting success therefore requires immediate study using experimental methods.

Comparison of published studies suggests that flammulated owls select prey opportunistically, and hence the owls do not engage in long-distance nomadic relocations in search of favored prey. The lack of nomadism, however, does not preclude a numeric response to prey fluctuation. Unpublished accounts of research conducted in British Columbia (St. John 1991, Van Woudenberg 1992) suggest a numerical response to a spruce budworm outbreak in that location, which is at the northern extreme of the owl's range. The New Mexico population studied by McCallum *et al.* (in review) fluctuated in numbers from year to year and showed little site fidelity, and hence may have been sensitive to prey numbers. The possibility that flammulated owls immigrate to areas experiencing outbreaks of forest insects should be investigated thoroughly.

Little is known of the population dynamics and ecology of prey species. Because the flammulated owl is not a prey specialist, obtaining comprehensive information on prey dynamics will not be easy, but the task should be undertaken. Study of noctuid and/or orthopteran communities would be a desirable way to begin.

Demography

It is known that limited fecundity imposes constraints on the demography of the flammulated owl, but other key aspects of its demography are poorly documented. The gaps in knowledge prevent definitive statements concerning demographic persistence, and no population is known to be self-sustaining (i.e., independent of immigration). Detailed study will be required to evaluate persistence of local populations and metapopulations under alternative management plans.

Evaluating the impact of alternative management plans on demography will require at least the following basic information: (1) Estimates of adult annual survival, preferably age-specific survival. Because of the high site-fidelity at the Manitou study area in Colorado, available but as yet unpublished data on return rates from Reynolds and Linkhart's study can be used to estimate age-specific survivorship. (2) Estimates of survival from fledging to age 1. It will probably be necessary to divide this parameter into two multiplicative categories. Estimating dispersal success will require new radio-tracking studies on a spatial scale at least 10 times greater than the typical contiguous population study. Available technology is sufficient to the task. Estimating overwinter survival of first-year birds should first be attempted on the assumption that dispersing birds return in the following spring to locations selected at the end of their late-summer dispersal movement. This can be evaluated either by rechecking late-summer settling sites of juveniles used in the dispersal study or by banding a large number of immigrants to a contiguous-territory study area. (3) Estimates of dispersal distances. The dispersal study described above will yield this information, which is required for assessing the metapopulation structure of a region, e.g., a mountain range.

The purported clustering of territories also deserves statistical study. First, the reality of such clusters should be tested. Then their permanency should be assessed, and if confirmed, habitat variables should be measured inside and immediately outside the clusters. Simultaneously, owl productivity in and dispersal from the clusters should be assessed.

Monitoring Methods

Abundance is a potentially misleading indicator of population health (Van Horne 1983). Survival and/or successful nesting are the only dependable criteria of habitat sufficiency. Moreover, vocal survey methods for monitoring abundance are undependable because vocal activity varies with mating status and environmental factors. Unmated males are more likely to vocalize than mated males, and male presence is not an indicator of habitat sufficiency because unmated males may occupy suboptimal territories. Studies are needed to compare the characteristics of territories occupied by pairs and those occupied by males only.

More intensive methods are available for reliably evaluating the response of flammulated owls to management alternatives. The most reliable information would come from intensive population studies, with management treatments applied experimentally to old forest sites where the owls had been studied for several years. Nest box monitoring programs (Hayward *et al.* 1992) have the potential to produce acceptably reliable information on a shorter-term basis. Nest box programs can also provide a sounder basis for statistical inference.

Dynamics of Primary Plant Communities Used by the Flammulated Owl

Fortunately the ponderosa pine plant community has been studied in great detail, and predictive models are available for forecasting the habitat consequences, at least for tree species and grass species, of current management prescriptions. The dependence of flammulated owls on arthropods subsisting on shrubby vegetation is unquantified. Greater knowledge of the dynamics of this segment of the plant community may be required.

Historic Patterns of Distribution and Composition of Forest Communities Used by the Flammulated Owl

Are the historic patterns of distribution and composition of forest communities used by flammulated owls understood in sufficient detail to place current status in a historic context? The historic distribution of the flammulated owl, though poorly documented, appears likely to have been coextensive with the current distribution. Forest structure and community composition are also thought to be well understood for the pre-European period. It is not at all clear, however, how the flammulated owl responded to the changes in its habitat over the past century. Whether the species is currently more or less abundant than before these changes is not known. The most critical information needed at present is whether current populations are viable or declining. Until such information is available, it should be assumed that current conditions are less favorable than were those before 1850. Policies with the goal of restoring present pine forests to presettlement physiognomy should be considered advantageous to the owl until the contrary is demonstrated. In order to clarify the relationship between forest composition and owl persistence, harvest of old yellow pine forest should be postponed, at least until before-harvest estimates of owl density and productivity can be obtained.

A RESEARCH PLAN

The information required to describe the conservation status of the flammulated owl falls into two categories that can be attacked with two different research strategies. In both cases, close coordination with Forest Service managers and researchers will be essential.

The first category is knowledge of the basic biology of the species, gaps that can be filled readily with short-term research projects. The second category is regional and continental trends in population dynamics, which should be designed and initiated by an experienced population biologist. A series of 16 nest box monitoring schemes, distributed throughout the range of the species in the United States, is recommended. Most data could be collected by local management personnel but should be analyzed and published in the peer-reviewed literature by an independent scientist. This approach will prevent charges of institutional bias in data analysis should the flammulated owl come under ESA at some time in the future.

A total of five short-term research projects is recommended for the owls. Useful research on competitors and predators is also outlined. These studies should be conducted by scientists having expertise appropriate to the research question, according to standard procedures. Some care should be given to conducting these studies at sites where appropriate habitat manipulations are underway or can be effected.

The continental project should be assigned to a scientist who can devote necessary time and attention to the conceptual development and interagency coordination required to set up a major continental monitoring scheme. It may be efficient to have a single scientist in charge of all facets of Forest Service research on the three forest owls covered by this document. In the first few years most work effort would be devoted to coordination; later, after research projects are in place, this person could analyze data from monitoring schemes for all three species.

The research strategy recommended for assessing viability of the United States flammulated owl population is somewhat revolutionary. It departs from standard practice in that it emphasizes demographic parameters and de-emphasizes surveys and studies of abundance. It is unusual because of its spatial scale. Since the 1940's it has been standard practice among academic ornithologists interested in population biology to conduct intensive studies of local populations. These studies have yielded invaluable information on territoriality, extra-pair copulation, site-fidelity, variation in reproductive success, and other essentials of breeding biology, but the investment in effort required to conduct such a study has usually been made at the expense of replication. Such studies are often erroneously generalized to the regional population or even the species, when in fact the sampling design does not justify inferences beyond the local population from which the data were obtained.

Devising a regional or national conservation strategy for the flammulated owl requires obtaining information throughout the geographic region covered by the plan. Intensive study of contiguous territories, as informative as it is, cannot be replicated sufficiently to provide the required breadth of coverage. A nest box monitoring program described by Hayward *et al.* (1992) appears to offer an efficient strategy for gaining dependable information on the necessary spatial scale.

Nest box schemes appear to offer multiple benefits. They increase ease of access, allowing an increase in sample size over studies of contiguous territories. Placement can be partitioned among different habitat types, allowing assessment of habitat effects on a variety of performance categories (e.g., foraging success, nesting success). Finally, experience gained with them will be applicable to management efforts. Hayward *et al.* (1992) estimated that setting up a sufficiently large nest box monitoring system (approximately 300 boxes along existing roads in a single district, checked twice a summer by district personnel) would cost less than $10,000 in material and labor. Annual maintenance and data gathering would cost less. Flammulated owls are not known for preferential use of boxes when cavities are available, but this may be due to particular preferences for the placement of boxes. A pilot study could be undertaken to assess the preferences of these owls for box placement. If this study is successful, I would envision the establishment of 16 300-box systems throughout the range of the species in the United States. Three box studies would be conducted in the Pacific Southwest, Southwestern, Rocky Mountain, Intermountain, and Pacific Northwest Regions, and one in the Northern Region.

Information needs for devising national and regional conservation strategies have been synthesized into a series of coherent projects that are outlined below. A mere list could lead scientists to say that they can meet these needs with projects of their own conception. An efficient strategy requires that information needs be met in an integrated rather than piecemeal fashion. The nest box monitoring scheme comprises items III.A and III.B below. Several of the short-term projects can and should be done wholly or in part in coordination with this scheme.

Finally, the long-term population study being conducted by Richard Reynolds at Manitou Experimental Forest should be extended indefinitely. Not only has this study yielded the vast majority of the behavioral, reproductive, and ecological information presently available on the flammulated owl, it is the only study ever conducted over a time span sufficient to show population trends. Continuing this study would allow future comparisons of population dynamics with climate and habitat change. Reynolds' data alone are sufficiently detailed to allow estimation of vital rates now. The historical record of home range use at this study site would facilitate several of the graduate projects outlined below. Finally, a nest box network established in and adjacent to the study site would allow validation of the nest box project's assumptions and it would provide enhanced opportunities for detecting long-distance dispersal.

Outline of Suggested Research Projects

I. REGIONAL VARIATION

Project conducted at a national center of excellence in systematics, with historical commitment to research in Mexico

A. Modern morphometric study of existing specimens (coloration is not reliable because of fading)

B. Assessment of genetic variation throughout the range of the species, using molecular techniques

C. Identification of winter range of U.S. breeding populations

1. Comparison of morphometric and molecu-

lar data from United States and Mexico
2. Field study of overlap of wintering and resident individuals, based on mist-netting or collecting

D. Taxonomic revision

II. HABITAT REQUIREMENTS OF INDIVIDUALS

A. Thermoregulatory capabilities — Short-term project (~2 years)
1. Laboratory respirometry at different relative humidities and ambient temperatures
2. Thermal properties of nest sites and roost sites in preferred, acceptable, and unoccupied home ranges. (Manitou Experimental Forest is best site because of long history of home range use)

B. Habitat selection by individuals — Experimental and observational study. Requires access to a Forest Service unit where habitat manipulations can be effected
1. Contribution of floristics (i.e., food), structure (thermoregulation and foraging), and competition to preference for yellow pine
2. Contribution of food, roost sites, and nest sites to preference for old forest
3. Characteristics of bachelor male territories in comparison with pair-occupied territories

C. Familiarity with territory — Short-term project, best conducted at Manitou Experimental Forest because of long history of home range use, with comparative data from other populations (see III.)
1. Contribution of age and familiarity with territory to foraging efficiency: observational and experimental
2. Contribution of food abundance and foraging efficiency to reproductive success (including clutch size), including artificial provisioning

III. VIABILITY OF SPECIES: POPULATION TRENDS AND VITAL RATES

A. Trends (presence/absence repeated annually)
1. Historic collecting sites
2. Representative owl transects

B. Current viability in reference populations throughout U.S. range, using nest box networks that span stand types
1. Annual variation in population size
2. Vital rates, intrinsic rates of increase
3. Immigration, emigration, net flux of individuals

C. Cavity recruitment and availability
1. Interspecific relations, including experimental study of ability of flammulated owls to usurp and hold cavities
2. Modeling of competitor dynamics

D. Metapopulation structure — Coordinated short-term studies
1. Based on molecular techniques
2. Intensive study of dispersal in one population
3. Modeling of metapopulation dynamics

IV. COMMUNITY INTERACTIONS

A. Community study of prey availability from April through October

B. Population dynamics of major prey species, e.g., noctuid moths

C. Comparative diet of bats and flammulated owls

D. Cavity competition between owls, other birds, and mammals

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