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DEMOGRAPHY OF NORTHERN SPOTTED OWLS ON THE ROSEBURG DISTRICT OF THE BUREAU OF LAND MANAGEMENT, OREGON

JANICE A. REID, ERIC D. FORSMAN, AND JOSEPH B. LINT

INTRODUCTION

Although it is generally thought of as a range management agency, the USDI Bureau of Land Management (BLM) is responsible for managing more than 890,670 ha of federal forest land in western Oregon (Richardson 1980). Historically, timber production was the primary focus on these lands. In recent years, however, the BLM has become increasingly involved in the management of habitat for wildlife and other non-timber resources. One of the primary factors that led to this shift in management focus was concern that species like the Northern Spotted Owl (*Strix occidentalis caurina*) may be adversely effected by the systematic conversion of old forests to intensively managed young forests (Thomas et al. 1990).

When it become apparent that long-term management plans were needed for the Northern Spotted Owl, wildlife biologists in the BLM and U.S. Forest Service became interested in trends in the vital rates of the owl as a possible indicator of the health of the Spotted Owl population, and as a means of documenting long-term changes in the owl population. To assess these trends, we monitored survival and reproductive rates of Spotted Owls from 1985–1993 on the Roseburg District of the BLM, located in the Umpqua River Basin in western Oregon. We also collected information on emigration rates of young owls in order to estimate the effects of emigration on survival estimates from capture-recapture data. Our objective was to provide information that would help managers and scientists better understand the status of the owl population in western Oregon and that could be used as base-line information for formulation of management policy. Herein we describe trends in survival and reproductive rates of Spotted Owls and estimate population trends based on the observed vital rates.

STUDY AREA

The 6,044 km^2 Roseburg Study Area includes lands administered by the Roseburg District of the BLM and intervening private lands (Fig. 1). With the exception of agricultural and residential areas in the Umpqua valley near Roseburg, the terrain is mountainous. Elevations range from 24–1418 m. A complex network of logging roads is present, providing access to most drainages. Summers are warm and dry and winters are cool and wet. Annual precipitation from 1985–1993 averaged 108 cm, with most precipitation occurring as rain from late fall to early spring (unpublished records, Douglas County Public Works Dept., Roseburg, OR). Temperatures infrequently registered below 0°C or above 38°C.

The Roseburg Study Area includes portions of three different physiographic provinces in western Oregon (Franklin and Dyrness 1973). The Coast Ranges Province northwest of Roseburg and the Western Cascades Province east and southeast of Roseburg are both dominated by forests of Douglas-fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), and western redcedar (*Thuja plicata*). The Klamath Mountains Province includes the area south of Roseburg, and is characterized by mixed-conifer forests of grand fir (*Abies grandis*), Douglas-fir, sugar pine (*Pinus lambertiana*), incense cedar (*Calocedrus decurrens*), golden chinquapin (*Castanopsis chrysophylla*), live oak (*Quercus* spp.), and pacific madrone (*Arbutus menziesii*) (Franklin and Dyrness 1973).

Land ownership on the study area consists of a "checkerboard" pattern of alternating square mile (2.59 km^2) sections of federal and non-federal lands (Richardson 1980). Because of different rates of tree harvest on federal and non-federal lands, age classes of forest within the study area are not uniformly distributed. Forests on most non-federal lands are largely characterized by younger stages of forest growing on cutover areas (mostly <79-yr-old stands). Lands administered by the BLM have not been as extensively harvested as non-federal lands, and include a diverse mix of young forests on cutover areas and older unlogged forests (80–450 years old). By 1992, approximately half (80,020 ha) of the 167,918 ha administered by the Roseburg District was still covered by older forests with dominant trees ≥120 years old (USDI 1992).

Historically, logging on the study area occurred largely in older stands. The primary method of harvest was clear-cutting, followed by replanting with Douglas-fir. This pattern changed somewhat after 1990, when court injunctions curtailed cutting of old forests on lands admin-

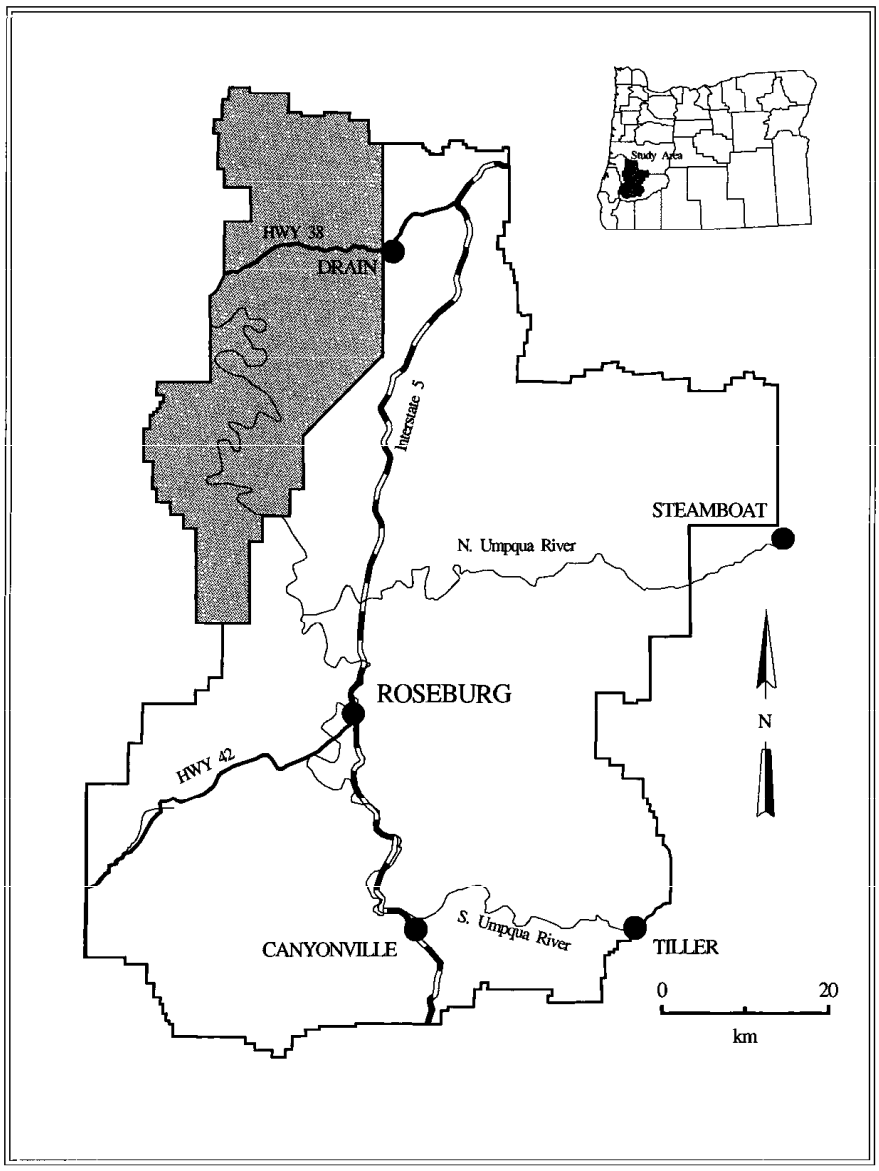

FIGURE 1. The Roseburg Northern Spotted Owl Demographic Study Area in western Oregon, 1985–1993. The study area included a 1,011 km² Density Study Area subplot (shaded area), within which we attempted to estimate the number of resident owls each year.

istered by BLM in Oregon (Portland Audubon vs. Lujan 1987, Lane County Audubon vs. Jamison 1991). As the cutting of older forests on public lands decreased, harvest of stands of young trees on non-federal lands increased.

The Roseburg Study Area was surrounded on three sides by other Spotted Owl demographic study areas (see Fig. 1 in Franklin et al. *this volume*). This was an ideal situation from the standpoint of a banding study, in that there was a high likelihood that banded owls that emigrated from the Roseburg Study Area would be detected by researchers on adjacent study areas, thus reducing the frequency of undetected emigration.

METHODS

We used mark-recapture techniques to estimate survival of banded owls. Methods used to locate, band, and recapture or resight owls are described in Franklin et al. (*this volume*). Survival rates for each sex and age class were calculated from capture-recapture data using Cormack-Jolly-Seber open population models in Program SURGE as described in Pollock et al. (1990), Lebreton et al. (1992), Franklin et al. (*this volume*), and Burnham et al. (*this volume*). Akaike's Information Criterion (AIC) (Akaike 1973, Anderson et al. 1994) was used to identify

models that best fit the data. Goodness-of-fit to the statistical assumptions in capture-recapture models was evaluated using Tests 1–3 in program RELEASE (Pollock et al. 1985, Burnham et al. 1987, Franklin et al. *this volume*).

Juvenile Spotted Owls often disperse beyond the boundaries of a given study area (i.e., they emigrate). Because emigration is usually indistinguishable from mortality in capture-recapture data, juvenile survival estimates from Cormack-Jolly-Seber open population models may be biased low. To estimate emigration rates of juvenile owls (E_J) we placed 5-gram radio transmitters on the rectrices of a subset of the 1991 and 1992 juvenile cohorts and followed the radio-marked owls for 2 years, or until they died or their transmitters failed.

Emigration rates were calculated using individuals that were still alive and whose radio-transmitters were still functioning in the spring following their first year of life (see also Burnham et al. *this volume*). Radio-marked juveniles whose fate could not be determined or that died before 1 April of the year following birth were not included in estimates of emigration. Emigration was defined as any case in which a radio-marked bird moved into an area not normally searched during our annual calling surveys, survived through March of the year following birth, and was not detected by our normal calling surveys (Burnham et al. *this volume*). This definition was adopted for the following reasons: (1) a bird that stays within the original study area is still susceptible to recapture and will be correctly treated by capture-recapture models; (2) a bird that leaves the original study area but is captured elsewhere will be reported to the original study area and treated as a recapture; and (3) only owls that emigrate and survive remain in the population; a bird that emigrates and dies has the same effect on the population as one that dies without emigrating. Clearly, the emigration rate defined here will be specific to the study area in which it is estimated.

Estimates of E_J from the radio-marked juveniles were used to adjust estimates of juvenile survival from capture-recapture data ($\hat{\phi}_J$) using the formula:

$$\hat{S}_J = \hat{\phi}/(1 - \hat{E}_J)$$

where $\hat{S}_J$ = the adjusted estimate of survival. For purposes of this analysis we assumed that annual survival probabilities were the same for emigrating and non-emigrating individuals, that emigration rates during the two years of study were representative of all years, and that tail-mounted transmitters did not influence emigration rates.

Mean annual fecundity (mean number of female young produced per female owl per year) was estimated by locating pairs or single female owls during the day during the breeding season and counting the number of young detected on each visit. Visits to locate and confirm the number of young followed a standardized protocol (Franklin et al. *this volume*). To estimate fecundity we divided the number of young observed by 2, assuming a 50:50 sex ratio. Annual and age-specific variation in fecundity were examined with ANOVA in program SPSS (Norušis 1990).

The annual rate of population change (λ) was estimated by solving the characteristic equation resulting from a modified stage-based Leslie matrix (Franklin et al. *this volume*). One estimate of λ was based on age-specific fecundity estimates and estimates of juvenile and non-juvenile survival from the best age-specific capture-recapture model. A second estimate of λ was based on the same parameter estimates as the first except that it included the estimate of juvenile survival that was adjusted to account for emigration.

To examine changes in numbers of territorial owls over time we conducted complete annual surveys of a 1,011 km^2 Density Study Area (DSA) within the boundaries of the Roseburg Study Area (Fig. 1). The Density Study Area was located in the Coast Ranges Province in the northwest corner of the Roseburg District. Survey routes in the Density Study Area were designed to insure complete coverage, including calling routes through all historical nest areas as well as calling stations spaced at 0.3–0.5 km intervals along roads throughout the area. We attempted to band all owls detected in the area. Because survey effort and size of the Density Study Area changed from 1987 to 1990, we present estimates of owl numbers in that area only for the period 1990–1993, when effort and coverage were essentially constant. Survey effort outside the Density Study Area focused mainly on areas with a history of occupancy by Spotted Owls.

Trends in the total number of territorial owls detected each year within the DSA were assessed with regression analysis in SPSS (Norušis 1990) to test the null hypothesis of no change in population size. A power analysis of the regression (Gerrodette 1987) was conducted using Program TRENDS (T. Gerrodette, personal communication). For all statistical tests, P values ≤ 0.05 were considered significant.

RESULTS

We developed capture histories on 476 $\geq$3-yr-old owls (214 females, 262 males), 117 1- and 2-yr-old owls (58 females, 59 males), and 429 juveniles. Goodness-of-fit tests of the data from $\geq$3-yr-old owls indicated some lack of fit for TEST 2. This suggested that there may have been

TABLE 1. GOODNESS OF FIT TESTS FROM PROGRAM RELEASE (BURNHAM ET AL. 1987) FOR SPOTTED OWL CAPTURE-RECAPTURE DATA SETS FROM THE ROSEBURG STUDY AREA, OREGON, 1985–1993

Sex/age	TEST 2 + 3[a]			TEST 2	TEST 3
	χ^2	df	P	P	P
≥3-yr-old males	29.02	19	0.0656	0.0087	0.5393
≥3-yr-old females	26.93	20	0.1374	0.0831	0.3288
All non-juveniles	41.98	20	0.0028	0.0031	0.0742
Juveniles	154.38	21	0.0000	0.6748	0.0000

[a] Test 2 tests whether different cohorts have different future fates. Test 3 tests whether previously released individuals have the same future fates as newly released individuals (Burnham et al. 1987).

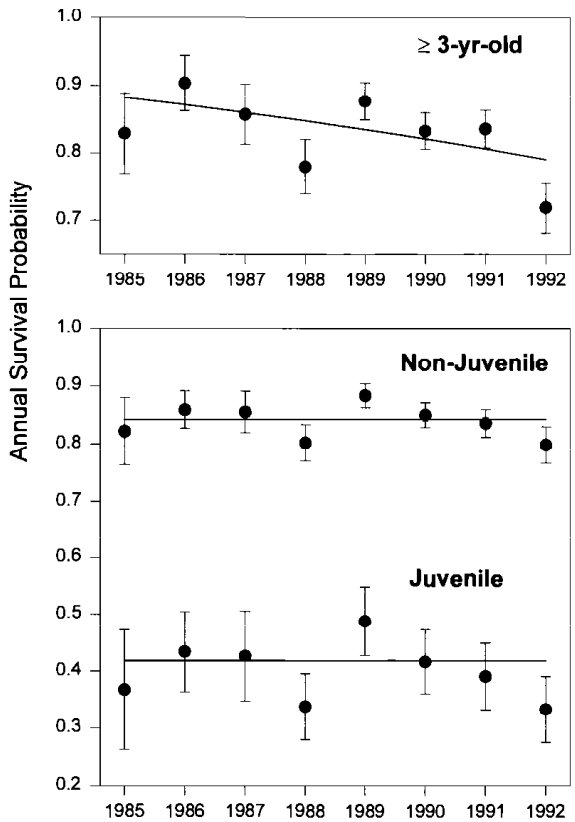

FIGURE 2. Estimates of survival of Northern Spotted Owls, Roseburg, Oregon, 1985–1993. The line in the top graph represents a nearly linear time trend in annual survival estimates for owls banded initially as ≥3-yr-old owls from model $\{\phi_T, p_{s+T}\}$. Point estimates and SEs of annual survival from a variable time model ($\{\phi_t, p_{s+T}\}$) are shown for comparison with the linear trend model. The lower graph depicts nearly linear time trends in annual survival estimates for juveniles and non-juveniles (solid lines), from the most parsimonious age-class model $\{\phi_{a2}, p_{a4'+s}\}$. Point estimates and SEs of annual survival from a variable time model $\{\phi_{a2+t}, p_{a4'+s}\}$ are shown for comparison. Non-juvenile survival estimates included owls first banded as ≥1-yr-old owls, plus that portion of the capture histories of juveniles beginning the year following banding.

some temporary emigration or lack of independence among owl resightings across years (Table 1) (Burnham et al. 1987). TEST 3 indicated no lack of fit for either males or females, or for all non-juvenile owls combined (Table 1). Scrutiny of the data indicated only a few individual owls were responsible for the lack of fit for TEST 2 and did not represent an overall lack of fit. The juvenile data failed TEST 3 (χ^2 = 148.623, df = 13, P < 0.001), but this test was not particularly reliable because the number of recaptures of juveniles was small. Since TEST 3 is sensitive to heterogeneity, the juvenile data may have failed TEST 3 because it was a mix of males and females, or because behavior and movements of juveniles were highly variable.

TEST 1 in program RELEASE indicated no difference in survival of males and females in the ≥3-yr-old age group (χ^2 = 23.26, df = 15, P = 0.079). TEST 1 was not conducted on the juvenile data because we did not determine the sex of many juveniles.

MODEL SELECTION

The most parsimonious capture-recapture model for ≥3-yr-old owls was one in which males and females had the same survival rate and in which survival declined linearly with time (model $\{\phi_T, p_{s+T}\}$, Table 2, Fig. 2). Likelihood ratio tests indicated no difference between the most parsimonious model and several other models, including one that had no annual variation in survival and another that indicated different survival rates for males and females (Table 2).

When four age classes were examined (juveniles, 1-yr-old owls, 2-yr-old owls, ≥3-yr-old owls), the capture-recapture model results indicated no differences in survival between 1- and 2-yr-old owls and ≥3-yr-old owls. As a result, all subsequent modeling was based on models in which owls were lumped into two age-classes (juveniles and non-juveniles). The most parsimonious model from the 2-age-class analysis was one in which juveniles and non-juveniles had different survival rates and survival did not vary

TABLE 2. COMPARISON OF SELECTED CAPTURE-RECAPTURE MODELS USED TO EXAMINE SPOTTED OWL DATA FROM THE ROSEBURG STUDY AREA, OREGON, 1985–1993. ONE SET OF MODELS EXAMINED ONLY OWLS BANDED AT AGE 3 OR GREATER. THE 2-AGE-CLASS MODELS INCLUDED TWO AGE CLASSES; JUVENILES (<1-YR-OLD), AND NON-JUVENILES (≥1-YR-OLD). MODELS WERE GENERATED IN PROGRAM SURGE (LEBRETON ET AL. 1992) AND ARE LISTED IN ORDER OF INCREASING AIC (AKAIKE'S INFORMATION CRITERION) VALUES (AKAIKE 1973). *K* IS THE NUMBER OF ESTIMABLE PARAMETERS. LIKELIHOOD RATIO TEST (LRT) RESULTS INDICATE WHETHER A PARTICULAR MODEL WAS SIGNIFICANTLY DIFFERENT THAN THE MODEL WITH THE LOWEST AIC

Model[a]	*K*	AIC	LRT χ^2	df	P
≥3-yr-old models					
$\{\phi_T, p_{s+T}\}$	5	1987.303			
$\{\phi_t, p_{s+T}\}$	11	1987.987	0.68	6	0.995
$\{\phi_T, p_{s*T}\}$	6	1988.821	1.52	1	0.218
$\{\phi, p_{s+t}\}$	10	1988.885	1.58	5	0.904
$\{\phi_{s+T}, p_{s+T}\}$	6	1989.187	1.88	1	0.170
2-age-class models					
$\{\phi_{a2}, p_{a4'+s}\}$	7	3236.954			
$\{\phi_{a2+T}, p_{a4'+s}\}$	8	3238.367	1.41	1	0.235
$\{\phi_{a2*T}, p_{a4'+s}\}$	9	3239.357	2.40	2	0.301
$\{\phi_{a2+t}, p_{a4'+s}\}$	14	3242.974	6.02	7	0.537
$\{\phi_{a2}, p_{a3'+s}\}$	6	3244.732	7.78	1	0.005

[a] Subscripts associated with model parameters indicate if there were categorical age (a), categorical sex (s) or time (t,T) effects on survival (ϕ) or recapture (p). Among-year variation in a parameter is indicated by a t (categorical) or a T (linear) subscript. Numbers indicate number of age-groups estimated by the model. An apostrophe following a number indicates that sex-effects were ignored for juveniles. An * indicates interaction between variables, whereas a + indicates a reduced model in which effects were additive.

with sex or time (model $\{\phi_{a2}, p_{a4'+s}\}$, Table 2, Fig. 2). Likelihood ratio tests indicated no difference between the most parsimonious model and several competing models (Table 2).

SURVIVAL ESTIMATES

Estimated annual survival ($\hat{\phi}$) from the best 2-age-class model was 0.419 (SE = 0.042) for juveniles and 0.843 (SE = 0.010) for non-juveniles. Estimates of non-juvenile survival from the most parsimonious model and the four competing models in Table 2 varied by less than 1%, indicating that model selection had little effect on survival estimates of non-juveniles. Estimates of juvenile survival were more variable than for non-juveniles, differing by as much as 7% among models. The estimate of juvenile survival from the best model was near the upper end of the range of survival estimates produced by the five 2-age-class models in Table 2.

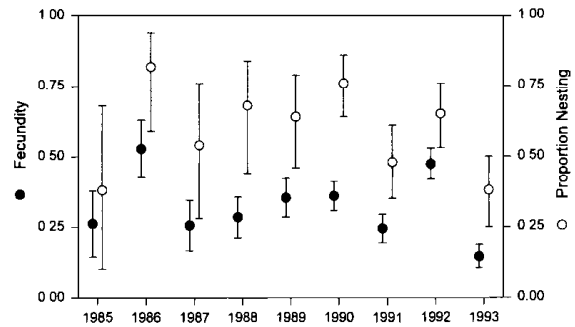

FIGURE 3. Annual fecundity and proportion of ≥3-yr-old female Northern Spotted Owls nesting on the Roseburg Study Area, OR: 1985–1993. Solid circles with associated SEs indicates fecundity, defined as the number of female young fledged per female owl. Open circles with associated 95% confidence intervals indicates proportion of females nesting.

JUVENILE EMIGRATION RATES

The rate of undetected emigration by radio-marked juveniles ($\hat{E}_J$) was 0.077 (SE = 0.052) for the 1991 cohort (2 of 26 owls emigrated), and 0.350 (SE = 0.086) for the 1992 cohort (11 of 31 owls emigrated). The pooled estimate was 0.228 (SE = 0.056; 13 of 57 owls emigrated). Using the pooled estimate of $\hat{E}_J$ to adjust the estimate of juvenile survival from the best 2-age-class model, we calculated an adjusted juvenile survival estimate ($\hat{S}_J$) of 0.542 (SE = 0.066), which was 12.3% higher than the unadjusted estimate.

FECUNDITY

Estimated mean annual fecundity of females was 0.321 (SE = 0.022, N = 697) for ≥3-yr-old owls, 0.144 (SE = 0.062, N = 52) for 2-yr-old owls, and 0.080 (SE = 0.056, N = 44) for 1-yr-old owls. Fecundity differed among years for ≥3-yr-old females (F = 7.572, df = 8, P < 0.001, Fig. 3). Fecundity of 1- and 2-yr-old owls was lower than ≥3-yr-old owls (F = 19.707, df = 1, P < 0.001). For this reason, we used the age-group estimates of fecundity for calculations of the annual rate of population change rather than a combined estimate for all females.

ANNUAL RATE OF POPULATION CHANGE

Based on the age-specific estimates of fecundity and the unadjusted estimates of juvenile and non-juvenile survival from model $\{\phi_{a2}, p_{a4'+s}\}$ we get $\hat{\lambda}$ = 0.957 (SE = 0.015), which is significantly less than 1.0 (z = 2.945, P = 0.002). Substituting the adjusted estimate of juvenile survival ($\hat{S}_J$) for the unadjusted estimate of juvenile survival ($\hat{\phi}_J$) in the population growth rate equation produced $\hat{\lambda}$ = 0.986 (SE = 0.020), which is not different

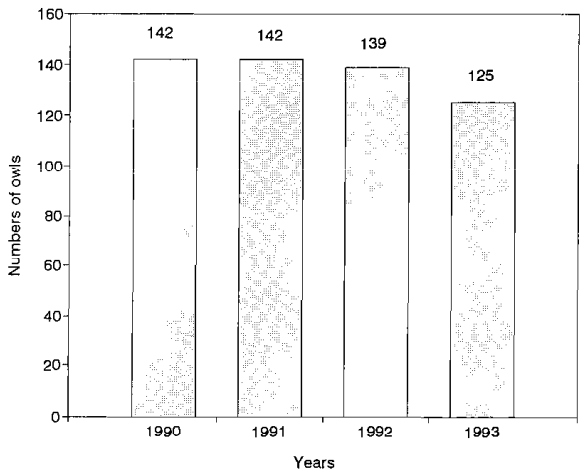

FIGURE 4. Number of territorial Spotted Owls detected on the Roseburg BLM Density Study Area during annual surveys conducted during the breeding season (1 March–31 August), 1990–1993.

from a stationary population (z = 0.706, P = 0.240). A power analysis of the latter test indicated that there was only a 17.2% chance of detecting a real population decrease of 1.4% per year with the available data.

Counts of Owls on the Density Study Area

Because the best 2-age-class model did not indicate any time effects on recapture probabilities, we assumed that the number of owls counted on the density study area each year could be compared without any correction for year-effects on detection rates. Although fewer owls were detected in 1992 and 1993 than in 1990 and 1991 (Fig. 4), the null hypothesis (no change in numbers of owls) could not be rejected (slope = −5.400, r = −0.858, P = 0.142). However, the power of the regression analysis (Gerrodette 1987) to detect the observed rate of decline was low (0.27).

DISCUSSION

Survival

It was not clear why the best model for ≥3-yr-old owls included a linear time trend on survival while the best 2-age-class model did not. One possibility was that pooling of 1- and 2-yr-old owls with ≥3-yr-old owls in the 2-age-class models produced more variability in the data, obscuring any linear trends. The linear decline in apparent annual survival of ≥3-yr-old owls is cause for concern because it could reflect some underlying problem with habitat. However, other explanations for the observed phenomenon should also be considered. For example, it is possible that a decline in survival rates observed during a relatively short-term study could be a natural oscillation around some equilibrium point.

In our analysis we assumed that the median capture interval for all age cohorts was one year. Deviations from this assumption could cause bias in estimates of survival.

Emigration

Because we did not have estimates of juvenile emigration (E_J) for every year of the study, we had little choice but to assume that pooled data from two radio-marked cohorts represented a reasonable average for all years of the study. This needs further investigation, especially in light of the fact that the estimates of E_J from the two radio-marked cohorts were quite different. However, in the absence of more years of data, we think it is reasonable to examine the potential influence of emigration based on the available data.

It has been suggested that prolonged periods of below average rainfall may have a deleterious effect on Spotted Owls (Noon et al. 1992), thus influencing survival and emigration rates. During the years that we estimated emigration rates, rainfall was comparable to the rest of the study period. From this standpoint, therefore, we did not feel that application of two years of emigration estimates to the entire study period was unreasonable. In fact, based on an analysis from several demographic study areas, an argument could be made that years of below average rainfall may be beneficial to Spotted Owls (E. Seaman, personal communication). Regardless of whether our data accurately estimated the average rate of emigration, they did provide clear evidence that juvenile emigration was relatively high in at least some years, and may have caused juvenile survival (ϕ_J) to be underestimated (Bart 1995, Burnham et al *this volume*).

Estimates of λ are particularly sensitive to non-juvenile survival rates (Noon and Biles 1990). If non-juvenile emigration occurs and is undetected, then non-juvenile survival rates may be underestimated, causing a corresponding underestimate of λ (Bart 1995). Although rates of non-juvenile emigration are generally believed to be low (Burnham et al *this volume*), some non-juvenile emigration does occur, as evidenced by occasional movements of non-juvenile owls from one study area to another (E. Forsman, unpublished data; J. Thrailkill, personal communication). To the extent that such movements occur and go undetected, they may cause non-juvenile survival rates to be underestimated. The Roseburg Study Area is somewhat unique in that it is surrounded on three sides by other demographic study areas where other researchers are

banding and monitoring Spotted Owls (see Franklin et al *this volume*). Given this arrangement of study areas, we believe the likelihood of undetected emigration by non-juvenile owls was particularly low for the Roseburg Study Area, but we have no data to prove this conclusively.

Fecundity

Causes for the considerable among-year variation in fecundity and proportion of females nesting were unknown. We suspect that variation in prey numbers coupled with long-and-short-term weather phenomena may have been primarily responsible for the observed variation in breeding. Fluctuations in prey populations have been implicated in breeding rates of a number of other owl species, including Great Horned Owls (*Bubo virginianus*; Rusch et al. 1972, Adamcik et al. 1978), Tawny Owls (*Strix aluco*; Southern 1970), Snowy Owls (*Nyctea scandiaca*; Pitelka et al. 1955), and Great Gray Owls (*Strix nebulosa*; Nero 1980).

Population Change

Depending on which estimate of λ was used, the population on the study area appeared to be declining at a rate of 1.4%–4.3% per year. These values might be viewed as a range within which λ could be expected to fall. However, there were other factors that could influence estimates of λ that we were unable to take into account. For example, in our analysis we did not include fecundity estimates from females that were known to be present, but that could not be visually observed well enough to confirm their age or color bands. Although some of these females were known to have nested, most were owls that appeared to be non-nesting or that nested and failed to produce young. Excluding these females tends to overestimate fecundity.

A factor that could have caused us to underestimate fecundity was mortality that occurred after young left the nest, but before brood size was determined (Bart 1995). We were unable to evaluate this bias, but think it was small because the number of young fledged by most pairs was determined within 1–2 weeks after the young left the nest.

Changes in Owl Numbers

The lack of a significant change in owl numbers on the Density Study Area did not necessarily confirm or refute the estimates of λ from the capture-recapture analysis. Assuming that a population decline is occurring, there are several factors that could cause changes in the density of territorial owls to lag behind the actual rate of decline in the population. In particular, it is possible that the number of territorial owls might not decline at the same rate as the overall population simply because the territorial population is maintained at a high level through replacement from within a "floater population" of owls without territories (Thomas et al. 1990, Franklin 1992). While this phenomenon might be expected to occur during the initial stages of a decline, it should gradually disappear, perhaps over many years, as the floater population is depleted.

Management Implications

Management of forest lands by the BLM and other landowners within the boundaries of the Roseburg Study Area has led to a reduction of suitable owl habitat during the last 40–50 years (Thomas et al. 1993a, Raphael et al. *this volume*). Even though rates of harvest on BLM lands have declined since 1990, habitat conditions are still changing fairly rapidly in the study area, particularly on private lands, where harvest continues at high levels. In this dynamic environment of changing habitat conditions, it is unlikely that the owl population will reach any sort of equilibrium condition for some time. Present trends in estimates of survival, fecundity, population growth rates, and owl numbers are reflective of past management activities, and do not necessarily indicate what will happen in the long term if there is a continued reduction in cutting of older forests on BLM lands and a commensurate recovery of suitable owl habitat within large areas of federal land that have been targeted for management of late-successional forest ecosystems (Thomas et al. 1990, Thomas et al. 1993b, USDA and USDI 1994).

The absence of strong negative trends in survival and counts of owl numbers on the Roseburg Study Area may indicate that the slowdown in harvest rates on BLM lands already may be having a stabilizing influence on the owl population. However, responses of the population are undoubtedly influenced by a variety of factors in addition to simple changes in habitat amount and distribution (e.g., weather patterns, predation rates, competition with invading species). While it is theoretically possible to address those relationships using experiments that control or account for all the different variables, we believe such experiments will be difficult or impossible to accomplish for a species with life history traits like the Spotted Owl (low population densities, large home ranges, high variation in vital rates, and high mobility). While this represents a challenge for researchers, it also represents a real problem for federal management agencies that are expected to document the effects of their management activities on native plants and animals. We think it is imperative that the public, the courts, and political representatives under-

stand that any management plan adopted for a species like the Spotted Owl is essentially an uncontrolled experiment. To expect that monitoring of such experiments will lead to simple conclusions is unrealistic. Thus, while we believe that management agencies should attempt to monitor the effects of their activities, we do not expect that the time will ever come when decisions regarding management will be judgment free. The challenge for resource managers will be to arrive at a judgments that are considered a reasonable compromise by vying interest groups.

SUMMARY

We conducted a capture-recapture study of Northern Spotted Owls on the Roseburg District of the Bureau of Land Management in western Oregon from 1985–1993. The study was designed to establish baseline estimates of vital rates of Northern Spotted Owls and to examine trends in those vital rates that might be indicative of overall population health. The study area was predominantly forest with alternating sections of federal and non-federal ownership. The sample of marked owls included 593 owls that were ≥1-yr-old (272 females, 321 males) and 429 juveniles. Males and females had similar survival rates, and there was little annual variation in survival. Estimated survival rates of juveniles and non-juveniles were 0.419 (SE = 0.042) and 0.843 (SE = 0.010), respectively. Fecundity, defined as the number of young produced per female per year, averaged 0.321 (SE = 0.022) for ≥3-yr-old owls, 0.144 (SE = 0.062) for 2-yr-old owls, and 0.080 (SE = 0.056) for 1-yr-old owls. Based on the capture-recapture data, the mean annual rate of change in the resident owl population during the study period ($\hat{\lambda}$) was 0.957 (SE = 0.015), indicating a 4.3% annual decline in the population of resident owls. The estimate of λ was significantly less than 1 (P = 0.002). When $\hat{\phi}_J$ was adjusted for juvenile emigration using information from radio-telemetry studies, $\hat{\lambda}$ was 0.986 (SE = 0.020), which was not different from 1.0 (P = 0.240). However, the power of the test to detect an annual population decline of 1.4% was low. The number of owls detected on a 1,011-km^2 area that was thoroughly surveyed each year did not decline significantly from 1990–1993. We suggest that the negative linear time trend on apparent survival rates of ≥3-yr-old owls could reflect a gradual loss of habitat or could simply be a mild oscillation around some equilibrium point.

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Key words: capture-recapture, demography, Klamath Province, Northern Spotted Owl, Oregon Cascade Ranges, Oregon Coast Ranges, population growth rates, *Strix occidentalis caurina,* survival.