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Reproduction and Mortality of Great Gray Owls in Oregon

Abstract

We observed population characteristics of great gray owls (*Strix nebulosa*) in northeastern Oregon from 1982 to 1986 for information needed to manage this species. Of 64 nesting attempts, 77 percent of the pairs raised young. Mean brood size was 2.3 (SD = 0.87, range = 1-5). Annual probability of survival of adult nesting females and males was 0.84 (CL = 0.70-1.00) and 0.91 (CL = 0.78-1.00), respectively. Probabilities of young owls surviving their first 12, 18, and 24 months of life were 0.53 (CL = 0.44-0.75), 0.39 (CL = 0.24-0.65), and 0.31 (CL = 0.16-0.57), respectively. This baseline information on reproduction and survival is essential to the management of populations of great gray owls.

Introduction

Great gray owls are uncommon throughout their range in North America. They were even considered rare in the United States until recently (Winter 1986, Franklin 1987, Forsman and Bryan 1987). Little is known of this species, yet information on the population dynamics is essential for the effective management of this owl. If a management goal is to maintain a specified population density over time, information is needed on reproduction, mortality, age of breeding, and life expectancy. These population characteristics of the great gray owl are addressed in this paper.

Study Area

The study was conducted in four study areas (called Spring, Bowman, Sheep, and Thomason) in northeastern Oregon. The Spring study area (44 km^2) was 17 km west of La Grande at 930-1140 m elevation. Cover types included conifer forest (63 percent of area), shallow-soiled grasslands (32 percent), and clearcuts (5 percent). Most of the forests in this area consisted of open, park-like stands dominated by ponderosa pine (*Pinus ponderosa*); 22 percent of this study area contained denser stands of Douglas-fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta*), and western larch (*Larix occidentalis*).

Bowman (27 km^2) was 50 km west of La Grande at 1380-1500 m elevation. Cover types included conifer forest (68 percent), shallow-soiled grasslands (20 percent), and clearcuts (12 percent). Dense stands of lodgepole pine or dense stands of grand fir (*Abies grandis*) and Douglas-fir with some western larch and ponderosa pine dominated the Bowman area.

Sheep (78 km^2) was 37 km southwest of La Grande at 1290-1500 m elevation. Cover types included confier forest (68 percent), clearcuts (12 percent), wet meadows along streams (12 percent), and shallow-soiled grasslands on ridges (8 percent). Ponderosa pine forests occurred on south-facing slopes, and lodgepole pine stands or mixed stands of Douglas-fir, western larch, and grand fir occurred on north-facing slopes.

Thomason (34 km^2) was 47 km north of Enterprise at 1350-1470 m elevation. Cover types included coniferous forest (71 percent) and wet meadows (29 percent). Forest stands were lodgepole pine and ponderosa pine or mixed stands of Douglas-fir, western larch, and grand fir.

Methods

We located owls by hiking through the study areas after dark in February, March, or April (1982-1986), and imitating the territorial call of a male great gray owl every 0.1 km. Areas where owls responded were searched during the day to locate nests. After a nest was found, we visited it weekly, if possible, to determine nesting success and productivity. We recorded brood size either by climbing to the nest within a week of fledging or waiting until after the young left the nest.

We compared dates that females started incubating and dates that young left the nest among study areas and years using a two-way

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analysis of variance and an LSD test for multiple comparisons. Sheep was not included in this analysis due to a small sample size. Nesting success was compared among study areas with a chi square analysis. Number of young raised was compared among study areas and years with a two-way analysis of variance. We chose $P < 0.05$ as the level of significance.

Adults were captured with a variety of traps including bal-chatris, noose poles, and mist nets (Bull 1987). We used 22-gm transmitters (AVM Instrument Co., Ltd., SM1, L Module) attached to the owl's back with a back-pack harness of 6-mm tubular teflon ribbon. Transmitter signals lasted 242-505 days.

Radio transmitters were attached to 10 adult males and 13 adult females and were replaced each year, if possible. All radio-tagged adults nested each year. Observation periods of radio-tagged owls were three years for 3 owls, two years for 7 owls, and one year for 13 owls.

We placed transmitters on 33 fledged juveniles which included all the young raised at Spring, Bowman, and Sheep in 1984 and 1985 and 3 young raised at Thomason in 1985. Observation periods of radio-tagged juveniles ranged from one year (30 individuals) to two years (3 individuals). Juveniles were weighed upon capture.

Radio-tagged owls were located from the ground every two weeks from the time they had a transmitter attached until they died, until the transmitter stopped, until we removed the transmitter, or until August 1986. To locate birds we could not find, we flew every two weeks searching within a 50-km radius of the study areas. Birds located while flying were then located from the ground. Locations of each bird were marked on aerial photographs.

Mortality and survival rates were calculated using Mayfield's (1975) method; confidence limits (95 percent) were calculated using Johnson (1979). One juvenile was not included in these calculations because we found only its transmitter on the ground, and we could not determine if the harness had broken or the bird had been killed and the transmitter torn off. We knew the fate of all other birds.

Results

Reproduction

In all study areas, incubation was initiated between 17 March and 17 April (Figure 1). There was a significant difference in onset of nesting among study areas ($P < 0.05$); owls in Spring nested earlier than owls in Thomason which again nested earlier than owls in Bowman according to an LSD test ($P < 0.05$, $N = 21$ nests). There was no year by area interaction ($F = 1.59$, $DF = 2$, $P = 0.24$) in nesting dates. In addition, some owls in Spring started incubating within three days of the same date each year in 1983-1986.

Brood size averaged 2.3 ($SD = 0.87$, Table 1). Brood size at 45 nests did not differ among study areas ($F = 0.10$, $DF = 2$, $P = 0.90$) or years ($F = 1.73$, $DF = 4$, $P = 0.17$), and there was no year by area interaction ($F = 1.74$, $DF = 7$, $P = 0.14$). We observed 8 broods with one young, 20 broods with two young, 15 broods with three young, 1 brood with four young, and 1 brood with five young.

All radio-tagged adults nested every year of observation. Of 64 nesting attempts, 77 percent of the pairs successfully fledged young (Table 1). No differences were found in nesting success among study areas ($P = 0.97$). Of the 15 pairs that failed to raise young, 9 failed during incubation, 4 failed with nestlings, and 2 were unknown.

We know of three pairs that renested after their first nesting attempt failed. These females renested 17-20, 28, and 30 days after nest failure, respectively. Of the three renesting attempts, only one was successful. In a fourth case, a female failed during incubation (egg shells on ground) and a new female (with transmitter) laid eggs on the abandoned nest 13-15 days after the first female left it. We did not know if the first female renested or if both females were mated with the same male as only one male was observed.

Young left the nest 52-74 days ($\bar{x} = 62$, $SD = 4.34$, $N = 18$ nests) after females started incubation. Assuming incubation lasted 36 days (Mikkola 1981), the mean number of days in the nest was 26 ($SD = 4.34$, range = 16-38 days, $N = 18$ nests). Even though there was a significant year by area interaction in fledging dates ($F = 3.29$, $DF = 5$, $P = 0.02$), the major difference was among study areas ($F = 6.11$, $DF = 2$, $P = 0.01$) and not among years ($F = 2.22$, $DF = 4$, $P = 0.10$). The significant interaction resulted from 1983 when the fledging dates were approximately the same in all areas. We think owls in Bowman, Sheep, and Thomason nested earlier in 1983, because there was less snow that

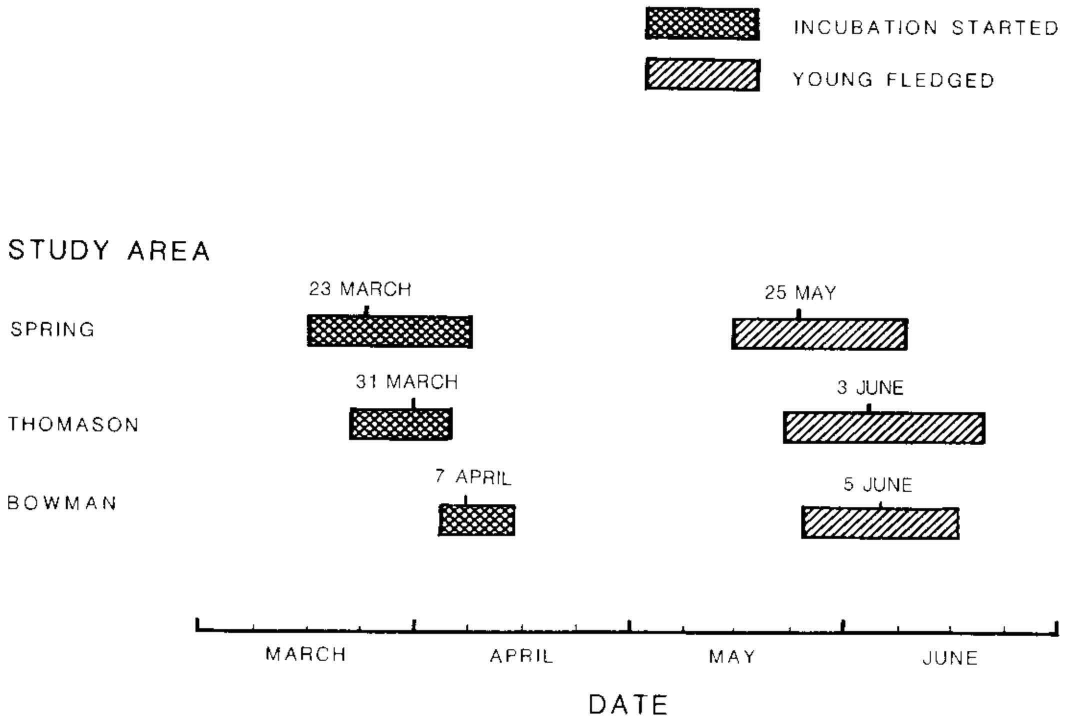

Figure 1. Nesting phenology of great gray owls in three study areas in northeastern Oregon, 1982-1986. Sample sizes were 13 nests in Spring, 5 in Thomason, and 3 in Bowman for the onset of incubation, and were 19, 10, and 6 nests, respectively, for dates young left the nest. Mean dates are identified for incubation and fledging periods.

TABLE 1. Productivity at great gray owl nests by study area in northeastern Oregon, 1982-86.

Study area	Nesting pairs N	Pairs that raised young (%)	Brood size $\bar{x}$	Brood size SD	Brood size Range
Spring	29	76	2.4	0.94	1-5
Thomason	19	79	2.3	0.91	1-4
Bowman	10	80	2.1	0.64	1-3
Sheep	6	67	2.0	1.00	1-3
Total	64	77	2.3	0.87	1-5

year than in the other years of the study. Owlets in Spring fledged earlier than owlets in Bowman and Thomason which were not different (LSD, $P < 0.05$, $N = 34$ nests).

For first annual nesting attempts, young left the nest between 14 May and 19 June. Young of renesting females left the nest between 22 June and 18 July. Owlets left over a period of several days, with the largest nestling usually being the first to leave. We never observed all young in a nest leaving on the same day. Five young in one nest left over a period of eight days. The mean weight of young when they left the nest was 609 g (SD = 75.08, range = 360-755 g, N = 81).

Twice we observed the adult owls favor the weakest of the fledglings. At one site where three young had left their nest, one young was blind in one eye, uncoordinated, and gurgled instead of hissed. The female stayed nearest to the blind owlet and the male fed it more frequently than the others. In another case, one of two fledglings was temporarily injured in handling and the female stayed with that young for several days until it could fly again.

After the young left the nest, the female stayed near their young, and the male continued to feed both the female and young. Usually after several days, the male took prey directly to the young and the female caught her own prey. Some females also caught prey for their young. After 3-6 weeks, 11 of 12 females were more than 1 km from their young and had apparently left the care of the young to the male. One female remained near the male and young for several months. Males continued to feed the young for more than three months after young left the nest. After three months, the young started to catch prey on their own.

We observed one exception to this pattern. At one nest, a female took over the care of her young when the male stopped delivering food (a few days before the owlets left the nest). Two young were in the nest at the time and left the nest 30 days after hatching. When they left the nest their weights were 360 and 530 g, which were well below the average weight of 609 g (CL = 592-626). The smaller owlet died several days later. The female continued to feed the juvenile for at least two months. During this time the male was alive and within 4 km of the nest, but we did not observe him feed the female or young.

Breeding Age

We followed 19 one-year-old owls and 3 (1 female, 2 males) two-year-old owls with transmitters, and none of them nested. One of the two-year-old males was with a female during the nesting season, but they did not nest. Two owls banded as fledglings were later found nesting as a two-year-old female and a three-year-old male at separate nests. Thus, great gray owls probably rarely breed at one year, sometimes at two years, and more commonly at three years.

Nest Failures

Cause of nest failures was varied. Broken eggs (uneaten) were found on the ground below two nests; they had apparently fallen through the nest. A nestling several days old was found dangling from a lichen below another nest. Single dead nestlings were found on the ground below two nest trees and had apparently fallen out. Two nests contained addled eggs and were abandoned following incubation of 26 and 42-48 days, respectively. Twelve nests were lost to unknown causes; however, we suspect common ravens (*Corvus corax*) destroyed most of them as we found broken egg shells within 100 m of four of them. A feather from a great horned owl (*Bubo virginianus*) was found in a great gray owl nest shortly after the nestlings disappeared, suggesting that the cause of failure was great horned owl predation.

Mortality of Adults and Juveniles

One of 10 adult males and three of 13 adult females died during the observation period. Using Mayfield's method (1975) the annual probabilities of survival for adult nesting males and females were 0.91 (CL = 0.78-1.00) and 0.84 (CL = 0.70-1.00), respectively. Cause of death could not be conclusively determined; however, one bird had been plucked in a tree, indicating avian predation; one bird had the head eaten and the remainder of the body buried; the remains of one bird included a wing, the transmitter, and avian fecal material; and one bird had not been eaten. All the deaths occurred in the fall or winter.

Of 33 juvenile owls with transmitters, 9 died before they became independent of the adults, 5 died in the fall, and 1 died after it was a year old. Using Mayfield's method (1975) the probabilities of a juvenile surviving the first 12, 18, and 24 months were 0.53 (CL = 0.44-0.75), 0.39 (CL = 0.24-0.65), nd 0.31 (CL = 0.16-0.57), respectively. We concluded that great horned owls and northern goshawks (*Accipiter gentilis*) killed seven of the dependent juveniles based on plucked feathers and fecal material at the kill site. We also saw a great horned owl fly from a tree containing the carcass of a dead juvenile. Two juveniles apparently starved to death during the period parents were feeding them. Of the five independent juveniles that died, two died of avian predation, and three died of unknown causes.

We saw red-tailed hawks hit juveniles on two occasions. One of the juveniles was carried a short distance before it was dropped unharmed.

Discussion

Timing of incubation appeared to be related to elevation because the owls started incubating earliest at Spring, the lowest site. The study areas at higher elevations usually had more than 0.5 m of snow (reduced prey availability) in March while snow was usually gone by mid March in Spring. Franklin (1987) found that the date the first egg was laid was significantly correlated with snow depth at the onset of the breeding season. Other factors such as prey density or age of breeding owls may have differed among the study areas and affected the nesting dates; however, we have no data on this.

Timing of incubation and egg size in this study did not differ appreciably from results reported in other studies. Female great gray owls have been reported on eggs every month from March until June (Nero 1970, Collins 1980, Pulliainen and Loisa 1977, Winter 1986, Franklin 1987).

Franklin (1987) found that clutch sizes in North America were significantly smaller than those in Scandinavia; he also reported an annual mean brood size of 2.7 and 3.0 in southeastern Idaho and northwestern Wyoming. Mean brood size in this study ($\bar{x}$ = 2.3) was lower than Franklin's and lower than the 2.9 (range = 1-7) reported for great gray owls in Finland and Sweden (Mikkola 1981). Productivity at nests did not differ among years or study areas in this study. Franklin (1987) did not observe annual differences in productivity either, unlike the annual variations observed in Scandinavia, which were attributed to fluctuations in vole populations (Mikkola 1981). Nest success in this study was 77 percent; Franklin (1987) reported a nest success of 70.5 percent in Idaho and Wyoming.

Length of time in the nest has been reported elsewhere as 18-25 days (Höglund and Lansgren 1968), 20-29 days (Mikkola 1983), and 3-4 weeks (Nero 1984). Some of the young we observed were in the nest longer than previously reported.

Our observations suggest that adult great gray owls sometimes favor the smaller or weaker of their offspring. Nero (1970) observed similar behavior. These observations are contrary to the theory that the weakest are not attended in many raptors if resources are scarce (Newton 1979). However, if resources were not limiting in this situation, it would seem advantageous to produce the maximum number of offspring possible.

Our observation of females leaving the young 3-6 weeks after the young have left the nest has not been reported elsewhere. Both Nero (1980) and Mikkola (1983) reported that both parents stayed with the young for up to three months after fledging. We think females left to replenish their fat reserves or restore body condition. None of them renested. The one female we observed stay with the young probably did so because the male had quit feeding the young.

The high juvenile mortality observed in this study appears to be typical of great gray owls (0.53 mortality rate for first 12 months). No other mortality rates are available in the literature, although Mikkola (1981) reported that a large proportion of juveniles perish.

If juveniles survive to breeding age (2-4 years), annual survival rate is high for nesting adults (0.84 and 0.91 for females and males, respectively). Because we observed such low mortality for adults and observed many adults nesting each year of this study (5 nesting seasons), we think great gray owls are long-lived (10 to 20 years).

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Literature Cited

Bull, E. L. 1987. Capture techniques for owls. *In* R. W. Nero, R. J. Clark, R. J. Knapton, and R. H. Hamre (eds.) Proceedings of biology and conservation of northern forest owls. USDA Forest Service, Gen. Tech. Rep. RM-142. Pp. 291-293.

Collins, K. M. 1980. Aspects of the biology of the great gray owl, *Strix nebulosa* Forster. Univ. of Manitoba, Winnipeg. M.S. Thesis.

Forsman, E. D., and T. Bryan. 1987. Distribution, abundance, and habitat of great gray owls in southcentral Oregon. Murrelet 68:45-49.

Franklin, A. B. 1987. Breeding biology of the great gray owl in southeastern Idaho and northwestern Wyoming. Humboldt State Univ., Arcata, Cal. M.S. Thesis.

Höglund, N. H., and E. Lansgren. 1968. The great grey owl and its prey in Sweden. Viltrevy 5:360-421.

Johnson, D. H. 1979. Estimating nest success: the Mayfield method and an alternative. Auk 96:651-661.

Mayfield, H. F. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456-466.

Mikkola, H. 1981. Der Bartkauz *Strix nebulosa*. Die Neue Brehm-Bucherei 538. A. Ziemsen Verlag. Wittenberg-Lutherstadt.

__________. 1983. Owls of Europe. Buteo Books, Vermillion, South Dakota.

Nero, R. W. 1970. Great gray owls nesting near Roseau. Loon 42:88-93.

__________. 1980. The Great Gray Owl—Phantom of the Northern Forest. Smithsonian Inst. Press, Wash., D.C.

__________. 1984. Leaving the nest. Blue Jay 42:165-170.

Newton, I. 1979. Population Ecology of Raptors. Buteo Books, Vermillion, South Dakota.

Pulliainen, E., and K. Loisa. 1977. Breeding biology and food of the great grey owl, *Strix nebulosa,* in northeastern Finnish forest Lapland. Aquil. Ser. Zool. 17:23-33.

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Winter, J. 1986. Status, distribution and ecology of the great gray owl (*Strix nebulosa*) in California. San Francisco State Univ., Cal. M.S. Thesis.