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NESTING AND DIET OF LONG-EARED OWLS IN CONIFER FORESTS, OREGON

EVELYN L. BULL AND ANTHONY L. WRIGHT[2]
USDA Forest Service, Pacific Northwest Research Station, La Grande, OR 97850

MARK G. HENJUM
Oregon Department of Fish and Wildlife, La Grande, OR 97850

Abstract. Long-eared Owls (*Asio otus*) nested in extensive stands of grand fir (*Abies grandis*) in northeastern Oregon. Nineteen of 20 nests were in dwarf-mistletoe brooms (*Arceuthobium* spp.) in Douglas-fir (*Pseudotsuga menziesii*) trees. Young were raised at 70% of the nests, and brood size averaged 3.0. The northern pocket gopher (*Thomomys talpoides*) was the primary prey item both in frequency (56%) and biomass (74%). These observations differ from those reported previously for the Long-eared Owl in North America.

Key words: Long-eared Owl; nest habitat; reproduction; diet; Oregon.

INTRODUCTION

The Long-eared Owl (*Asio otus*) has a circumpolar, holarctic distribution in boreal, temperate, Mediterranean, and steppe climatic zones (Mikkola 1983). Because of its wide distribution and tendency to roost and nest in concentrations, much has been published on its food habits and nesting (Hagen 1965, Kallander 1977, Mikkola 1983). However, the majority of information reported has been for owls inhabiting small, scattered woodlands surrounded by open land (Wijnandts 1984, Marks 1986). No such information is available on this species in a predominantly forested habitat in North America. Our objectives were to describe the nesting habitat, reproduction, and diet of Long-eared Owls in extensive conifer forests in northeastern Oregon.

STUDY AREA

The study was conducted on a 5,270-ha area on the Starkey Experimental Forest (Starkey) 35 km southwest of La Grande in northeastern Oregon. Starkey is characterized by undulating uplands dissected by moderate to steeply walled drainages with elevations of 1,070–1,524 m. Fifty-one percent of the study area is in slopes (area between ridges and draws), 44% in ridges (areas with 0–10% slopes), and 5% in draw bottoms. Thirty-two percent of the slopes are northern aspects (316–45°), 31% are eastern (46–136°), 20% are southern (136–225°), and 16% are western (226–315°).

The study area consists of a mosaic of forests (84% of area) with many shallow-soiled grasslands (16%). Forest types in the study area (classified by Burr 1960) are 14% open ponderosa pine (*Pinus ponderosa*), 41% ponderosa pine-Douglas-fir (*Pseudotsuga menziesii*), and 45% grand fir (*Abies grandis*) mixed with Douglas-fir, ponderosa pine, and western larch (*Larix occidentalis*) (45%). Forested stands were uneven-aged and were classified into three successional stages: (1) stands with trees <30 cm dbh (diameter at breast height); (2) stands with trees 30–50 cm dbh; and (3) stands with trees >50 cm dbh. Ninety percent of the area had not been logged in 40 years; the remainder had a partial removal of the overstory within the last 15 years.

METHODS

We searched for Long-eared Owls from 15 March–25 May in 1987 and from 29 February–25 May in 1988, walking routes through the study area after sunset. Routes were <0.5 km apart to ensure that the entire area was covered. The study area was searched once prior to and once after 15 April each year. Along a route we stopped every 0.1 km, imitated the call of a Long-eared Owl, and listened 3 min for a response. If an owl was heard, we recorded date, time, and location.

To locate nests, we returned during the day to sites where owls had been heard and searched for whitewash, pellets, and potential nest plat-

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[2] Present address: Running Creek Ranch, P.O. Box 1515, Hamilton, MT 59840.

forms. Any tree with more than six pellets underneath it and within 150 m of a nest was defined as a roost tree. Pellets were identified by size, although Long-eared Owls were observed at approximately half these roosts. We identified the species of tree, type of roost (mistletoe or branch), and measured dbh, height of roost, and distance from nest. Platforms with an adult bird in an incubation position, with eggs, or with nestlings (live or dead) were defined as nests. There were three cases where nests were found after the nestlings had left the nest but were in trees nearby. The nest was easily identified by the presence of whitewash and pellets underneath it and by pellets and Long-eared Owl feathers in the platform.

Nest sites were visited once a week to collect pellets and look for dead owls, prey remains, or fledged young. After the young had left, we climbed to each nest to collect pellets and prey remains and to measure (diameter and depth) and describe the nest platform. Skulls and dentaries in each pellet were identified with the use of keys (Maser and Storm 1970, Glass 1973). Skulls and dentaries of each species were summed, and the number of each species was determined by the number of skulls or pairs of dentaries, whichever was larger. Biomass consumed by the owls was estimated for each prey species according to Bull et al. (1989). Because of variable weights of birds and their relative insignificance in the diet, avian species were not considered in biomass calculations.

The age of northern pocket gophers (*Thomomys talpoides*) was determined using a regression formula in Janes and Barss (1985). All dentaries with a condyloid process length of ≥ 20 mm were classified as adults and those <20 mm were juveniles. We used 90 g for adults and 30 g for juveniles in biomass calculations.

We recorded the following characteristics of each nest tree: species, dbh, height, age, and presence of dwarf-mistletoe brooms (*Arceuthobium* spp.). The following habitat characteristics were recorded in a 0.1-ha circular plot centered on the nest tree: location (ridge, slope, or draw), slope aspect and gradient, forest type and successional stage, stem density, number of trees with dwarf-mistletoe, distance to opening >0.5 ha, number of canopy layers, logging activity, and canopy closure (four readings at nest using spherical densiometer). Within a 500-m radius of each nest, the percent of area in forests and openings was measured with a planimeter on aerial photographs.

The following habitat characteristics in 40 0.1-ha plots selected at random in grand fir forest types within the study area were recorded: successional stage, slope gradient, number of canopy layers, logging activity (none or partial removal), and number of trees with dwarf-mistletoe.

Chi-square analyses were used to compare nest-site characteristics with characteristics in random plots: (1) in ridges, slopes, and draws; (2) in north, east, south, and west aspects; (3) in three forest types; (4) in number of canopy layers; (5) in logging activity; and (6) in successional stage. We compared the slope gradient and number of trees with dwarf-mistletoe brooms at nest sites with the gradient and number of trees with dwarf mistletoe at random plots (unpaired two-tailed t-test). Significance was defined when $P \leq 0.05$.

RESULTS

REPRODUCTION

The first Long-eared Owl was heard on 18 March in both 1987 and 1988. In 1987 and 1988, respectively, 25 and 34 owls were heard during sampling, and 88% and 53% were heard before 26 April. Owls were heard calling from an hour before sunset until 7 hr after sunset. Vocal activity was greatest within 2 hr of sunset when 63% of the owls were first heard, yet only 26% of the time spent listening was within this 2-hr period.

Clutch size at five nests ranged from three to five eggs; we observed females on eggs from 15 April to 26 May. Mean brood size of 12 nests within a week of when young started branching (climbing out branches away from the nest) was 3.0 (SD = 1.2, Range = 1–4). Young started branching from 13 June until 1 July.

Young were successfully raised ($\geq$one young left the nest) at 14 (70%) of 20 nests. Nine of the nests were found during incubation, eight during brooding, and three after branching. Fifty-six percent of the nests found during incubation were successful. Remains of depredated nestlings were found at two nests, and remains of a depredated adult were found at one nest. We found remains of three fledged juveniles that had been killed by *Accipiter* spp. Accipiter pluck sites containing remains of Long-eared Owls in the vicinity of five Long-eared Owl nest sites suggested that other

TABLE 1. Diet of Long-eared Owls during nesting in northeastern Oregon, 1987–1988, determined from 1,128 pellets (1,123 prey items).

Prey item	Weight	% Biomass	% Frequency
Mammals			
Northern pocket gopher	30, 90[a]	74.4	55.7
Vole (*Microtus* spp.)	26	15.2	20.5
Deer mouse (*Peromyscus maniculatus*)	16	5.4	11.8
Bushy-tailed woodrat (*Neotoma cinerea*)	156	3.2	0.7
Red-backed vole (*Clethrionomys gapperi*)	19	0.9	1.6
Shrew (*Sorex* spp.)	5	0.5	3.3
Other mammals[b]		0.5	0.3
Birds			3.9
Insects			2.2

[a] Weight (g) used for biomass calculations; 30 g used for juvenile and 90 g used for adult pocket gophers.
[b] Included prey comprising <0.5% of diet: heather vole (*Phenacomys intermedius*) (27 g), yellow-pine chipmunk (*Eutamius amoenus*) (56 g), and northern flying squirrel (*Glaucomys sabrinus*) (115 g).

adults had been killed. In addition, a Long-eared Owl leg was found in a Great Horned Owl (*Bubo virginianus*) nest.

DIET

We collected 1,128 pellets from Long-eared Owl nests and roosts located within 150 m of occupied nests. The northern pocket gopher was the primary prey item both in frequency and biomass (Table 1). Of the pocket gopher dentaries 72% were from juveniles and 28% were from adults. Adults accounted for 40% of the biomass, and juveniles for 34%. *Microtus* spp. made up 20.5% of the diet (15.4% *M. montanus*, 1.7% *M. longicaudus*, and 3.4% unknown).

Forty-four bird skulls were found in the pellets, and feather remains of 20 birds were found in or near nests. These feathers included remains of three Mountain Bluebirds (*Sialia currucoides*), two Western Bluebirds (*S. mexicana*), two Northern Flickers (*Colaptes auratus*), two Williamson's Sapsuckers (*Sphyrapicus thyroideus*), one Stellar's Jay (*Cyanocitta stelleri*), one Clark's Nutcracker (*Nucifraga columbiana*), one Brown-headed Cowbird (*Molothrus ater*), one American Robin (*Turdus migratorius*), one European Starling (*Sturnus vulgaris*), one Dark-eyed Junco (*Junco hyemalis*), one Chipping Sparrow (*Spizella passerina*), and one warbler (*Vermivora* sp.).

One insect was identified as a ponderous borer (*Ergates spiculatus*).

NESTING HABITAT

We located 20 nests in 1987–1988. All nests were in Douglas-fir trees which averaged 31 cm dbh (SD = 9.97), 21 m tall (SD = 5.91), and 87 years (SD = 24.65) of age. Nest height averaged 9.8 m (SD = 3.24). Nineteen of the nests were in dwarf-mistletoe brooms, and one was a stick nest—probably built by an accipiter. The mean dimensions of nest platforms were 49 (SD = 13.5) × 35 cm (SD = 9.98) with a mean depth of 23 cm (SD = 8.93). All of the nests were supported by branches, but the actual nest contents were needles at 14 nests, twigs at four nests, and grass at one nest. The canopy closure over nests averaged 62% (SD = 22.03).

There was a significant difference in nest use among forest types, as all 20 nests occurred in the grand fir type ($\chi^2 = 24.4$, df = 1, $P < 0.01$). Owls selected nest sites in unlogged stands ($\chi^2 = 3.96$, df = 1, $P = 0.05$) with a high number of dwarf-mistletoe brooms ($t = 2.7$, df = 58, $P = 0.01$). Plots at nest sites contained an average of 9.1 trees (SD = 8.11) with dwarf-mistletoe brooms, while random plots contained an average of 3.7 (SD = 5.29).

By comparing nest sites with random plots, there were no significant differences among slope aspects ($\chi^2 = 3.19$, df = 3, $P = 0.38$); ridges, slopes, or draws ($\chi^2 = 1.17$, df = 2, $P = 0.57$); slope gradient ($t = 0.01$, df = 58, $P < 0.50$); number of canopy layers ($\chi^2 = 0.62$, df = 1, $P = 0.45$); or successional stages ($\chi^2 = 3.42$, df = 2, $P = 0.20$).

Nest sites contained an average of 85.5 stems <10 cm dbh (SD = 55.9), 47.7 stems 10–50 cm dbh (SD = 10.8), and 1.6 stems >50 cm dbh (SD = 1.79) in 0.1-ha plots. Canopy closure around the nest tree averaged 80% (SD = 15.7). Nineteen of the 20 nests were not within 30 m of an opening (>1 ha in size); average distance

to an opening was 105 m (SD = 58.8). Within 500 m of nests the amount of area in forest and opening averaged 79% (SD = 6.48) and 21% (SD = 6.09), respectively.

At least six pellets were collected from each of 37 roost trees in the vicinity of nests. These roosts averaged 39 m (SD = 18.2) from the nest. Seventy percent of these roosts were in Douglas-fir, 24% in grand fir, and 5% in ponderosa pine. The roost trees averaged 31 cm dbh (SD = 12.88). Fifty-seven percent of the roost sites were in dwarf-mistletoe brooms. The remainder were on branches. Roost sites averaged 4 m (SD = 1.60) off the ground.

DISCUSSION

We discovered several characteristics of Long-eared Owl nesting habitat not previously reported in North America. First, Long-eared Owls nested in extensive conifer forests and were dependent on dwarf-mistletoe brooms in Douglas-fir as nest sites. In other studies, Long-eared Owls typically used stick nests built by corvids (Craig and Trost 1979, Wijnandts 1984, Marks 1986). Mikkola (1983) reported three of 256 nests in witches' brooms in Britain. We think that the owls nested in the smallest, most inconspicuous platform that would accommodate them, unlike Mikkola's (1983) observation that they used large old nests.

Second, all nest sites were in dense, unlogged stands of grand fir with no apparent regard for slope aspect or gradient. We think that the birds chose the grand fir forest type because of the cover afforded by the nearly closed canopy. In contrast, Mikkola (1983) reported that most Long-eared Owls nested in small patches of woodland among open meadows and fields.

We think the dense canopy cover reduced predation. We found depredated adults or young at eight of 20 nest sites. In spite of this predation we found higher nest success (70%) than Marks reported in Idaho (34–51%; 1986).

Only Craig and Trost (1979) reported a predominance of northern pocket gophers (43% by biomass) in the diet of Long-eared Owls. Janes and Barss (1985) noted that pocket gophers taken by Long-eared Owls were usually small with a mean weight of 41 g. Other studies reported a predominance of *Microtus* (Armstrong 1958, Glue and Hammond 1974, Hagen 1965, Mikkola 1983), *Apodemus* (Wooller and Triggs 1968), *Peromyscus* (Marti 1974), and heteromyids (Marks 1984) in the breeding diet.

Even though Long-eared Owls in our study area preyed heavily on a different species, juvenile pocket gophers, the prey-size distribution was consistent with that reported by Marti (1976) and Marks (1984), where most of the prey weighed <60 g. The juvenile pocket gophers were probably taken above ground, as Howard and Childs (1959) reported juveniles traveling along the ground in March, April, and May. Scheffer (1954) noted a spring and early summer dispersal of subadult pocket gophers above ground.

The high incidence of pocket gophers in the diet and the extensive amount of forest (86%) in our study area suggests that Long-eared Owls were foraging in forest stands. The 14% of the area in openings consisted of shallow-soiled scab flats—areas infrequently inhabited by pocket gophers due to the shallow soil. Davis et al. (1938) seldom found pocket gophers in soils <10 cm in depth. Consequently, we think the birds foraged for pocket gophers largely in open forested stands or along edges. Only Armstrong (1958) reported much foraging in woodlands; all other authors (Randle and Austin 1952, Marti 1974, Mikkola 1983, Marks 1984) observed foraging in open country.

Our observations revealed that these owls may be more abundant in conifer forests than previously thought and may point to a more opportunistic nature of this species.

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LITERATURE CITED

ARMSTRONG, W. H. 1958. Nesting and food habits of the long-eared owl in Michigan. Museum, Michigan State Univ. Biol. Series 1:61–96.

BULL, E. L., M. G. HENJUM, AND R. S. ROHWEDER. 1989. Diet and optimal foraging of great gray owls. J. Wildl. Manage. 53:47–50.

BURR, J. A. 1960. Soil survey, Starkey Experimental Forest and Range, Union and Umatilla Counties, Oregon. USDA Soil Conserv. Serv. and For. Serv.

CRAIG, T. H., AND C. H. TROST. 1979. The biology and nesting density of breeding American Kestrels

and Long-eared Owls on the Big Lost River, southeastern Idaho. Wilson Bull. 91:50–61.

DAVIS, W. B., R. R. RAMSEY, AND J. M. ARENDALE, JR. 1938. Distribution of pocket gophers (*Geomys breviceps*) in relation to soils. J. Mammal. 19: 412–418.

GLASS, B. P. 1973. Key to the skulls of North American mammals. Oklahoma State Univ., Stillwater.

GLUE, D. E., AND G. F. HAMMOND. 1974. Feeding ecology of the Long-eared Owl in Britain and Ireland. Br. Birds 67:361–369.

HAGEN, Y. 1965. The food, population fluctuations and ecology of the long-eared owl (*Asio otus* (L.)) in Norway. Norwegian State Game Res. Inst. Papers Ser. 2, No. 23.

HOWARD, W. E., AND H. E. CHILDS, JR. 1959. Ecology of pocket gophers with emphasis on *Thomomys bottae* Mewa. J. Agric. Science 29:277–358.

JANES, S. W., AND J. M. BARSS. 1985. Predation by three owl species on northern pocket gophers of different body mass. Oecologia 67:76–81.

KALLANDER, H. 1977. Food of the long-eared owl *Asio otus* in Sweden. Ornis Fenn. 54:79–84.

MARKS, J. S. 1984. Feeding ecology of breeding long-eared owls in southwestern Idaho. Can. J. Zool. 62:1528–1533.

MARKS, J. S. 1986. Nest-site characteristics and reproductive success of Long-eared Owls in southwestern Idaho. Wilson Bull. 98:547–560.

MARTI, C. D. 1974. Feeding ecology of four sympatric owls. Condor 76:45–61.

MARTI, C. D. 1976. A review of prey selection by the Long-eared Owl. Condor 78:331–336.

MASER, C., AND R. M. STORM. 1970. A key to Microtinae of the Pacific Northwest (Oregon, Washington, Idaho). Oregon State Univ. Bookstores, Corvallis.

MIKKOLA, H. 1983. Owls of Europe. Buteo Books, Vermillion, SD.

RANDLE, W., AND R. AUSTIN. 1952. Ecological notes on long-eared and saw-whet owls in southwestern Ohio. Ecology 33:422–426.

SCHEFFER, T. H. 1954. Concerning the pocket gopher in mole range. Wash. Agric. Exp. Stn. Circ. 242: 1–4.

WIJNANDTS, H. 1984. Ecological energetics of the Long-eared Owl (*Asio otus*). Ardea 72:1–92.

WOOLLER, R. D., AND G. S. TRIGGS. 1968. Food of the Long-eared Owl in Inverness-shire. Bird Study 15:164–165.