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Ecology of the Great Gray Owl

Evelyn L. Bull and Mark G. Henjum

Authors

EVELYN L. BULL is a wildlife biologist, USDA Forest Service, Pacific Northwest Research Station, Forestry and Range Sciences Laboratory, 1401 Gekeler Lane, La Grande, Oregon 97850; and MARK G. HENJUM is a nongame wildlife biologist, Oregon Department of Fish and Wildlife, 107-20th Street, La Grande, Oregon 97850.

Abstract

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Information is needed on the great gray owl to understand its ecology and to consider this species in land management decisions. From 1982 to 1988, we studied 24 pairs and 107 juvenile great gray owls in northeastern Oregon. Forty-nine nests were located; 16 were used more than once, so we observed 71 nesting attempts. Seventy-eight percent of these nesting attempts were successful in raising 1 to 5 young (mean = 2.2). The nests were on stick platforms, on top of broken-off dead trees, and on artificial wooden platforms. Nest trees occurred in a variety of habitats, although most were in mature or older, unlogged stands of mixed conifer. Diet by biomass consisted mainly of northern pocket gophers (67 percent) and voles (27 percent). The size of the home range for 16 adult owls and 19 juvenile owls averaged 67 square kilometers and 157 square kilometers, respectively. Management practices enhancing habitat for great gray owls include providing artificial nest platforms, protecting existing nest platforms and large-diameter dead trees, providing dense tree cover around or adjacent to the nest, and providing perches for recently fledged young.

Keywords: Owl, great gray owl, management, conifer forest, Oregon.

Preface

This paper is intended to be a general guide for biologists, ornithologists, and others interested in the ecology of the great gray owl. The detailed methods and statistical analyses have been deleted to save space and to promote readability. For persons interested in this information, it is available in the references by Bull and others listed in the literature cited at the end of the text. Scientific names are given in the appendix.

Contents

Introduction

Many people have sought the great gray owl, a striking bird standing 56 cm tall with a wing span in excess of 1.5 m. [1] It is easily recognized by its gray plumage; large, circular facial discs surrounding bright yellow eyes; and lack of ear tufts. Yet, this owl is not easily observed because of its low numbers, nocturnal habits, and secretive nature. Its range in North America is limited to some parts of Canada, Alaska, and the northern Midwest States, with local populations in Yosemite Park (California), south-central and northeastern Oregon, southeastern Idaho, and northwestern Wyoming (fig. 1).

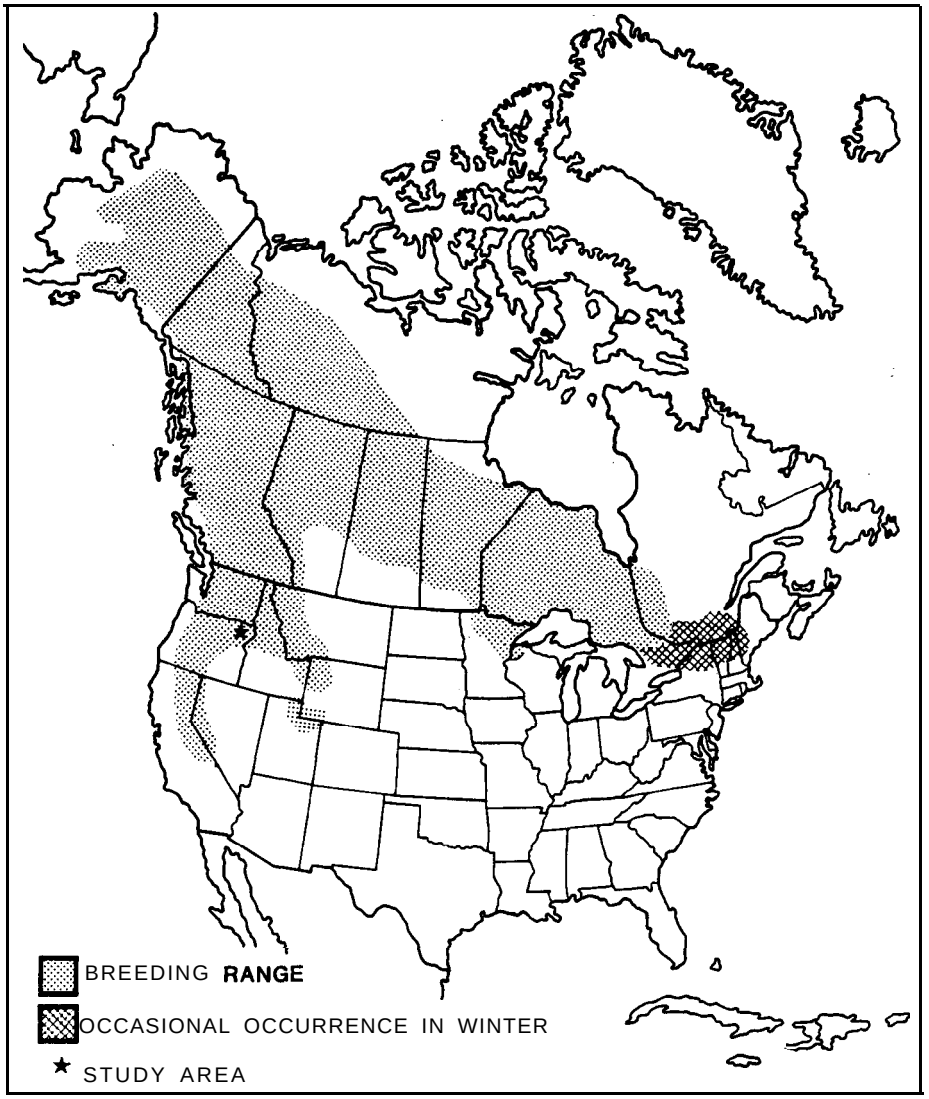


Figure l-Distribution of the great gray owl in North America.

[1] Scientific names for all plants, birds, and mammals are given in the appendix.

People in other parts of the world have investigated this cryptic bird (Franklin 1988, Mikkola 1983, Nero 1980, Servos 1986, Winter 1986), but there were great gaps of knowledge pertaining to the great gray owl in northeastern Oregon. We did not have a clue as to actual number of birds in our forests. After investigating the literature, we still did not know how the habits of the birds in Oregon differed from birds in Canada or Scandinavia. Our forest structure in northeastern Oregon is in some ways much different from that in other regions. We wondered how the great gray owl has adapted to these forests and whether they use nests similar to those used elsewhere. Do they eat similar prey items? Is the local population successfully reproducing year after year? For these questions, we had no answers.

Our study of the ecology of the great gray owl began in spring 1982 and lasted 6 years. The information presented here is a result of this investigation of more than 24 nesting pairs and 107 juveniles in four different study areas. We looked not only at reproduction, but also at the platforms and surrounding habitat used for nesting. We determined prey items used during nesting. We put radio transmitters on 23 adults and 32 juveniles and followed them for up to 3 years to gather information on breeding biology, mortality, and dispersal. In this way, we started solving the riddles surrounding the survival of this elusive, little-known owl of the Oregon forests.

Study Area

Our study was conducted in four study areas called Spring, Sheep, Bowman, and Thomason in Union, Umatilla, and Wallowa Counties in northeastern Oregon (fig. 1). All study areas were in predominantly forested landscapes interspersed with shallow-soiled grasslands or deep-soiled meadows. The forests were entirely coniferous and contained ponderosa pine, Douglas-fir, grand fir, western larch, and lodgepole pine. Terrain ranged from gently sloping to steeply walled drainages (fig. 2). Elevations were between 930 and 1,500 meters.

Figure 2—Aerial view of great gray owl habitat in northeastern Oregon.

Locating Birds

The first challenge was to locate these elusive owls. They are primarily nocturnal, like most owls, so we searched for them after dark in March and April. We concentrated our efforts where we had historical sightings. We walked routes through perspective areas, stopping every 0.1 kilometer to listen for owls. If none was heard, we imitated the territorial call of a male great gray owl (a series of 6 to 10 low "whoos") three times and listened for about 3 minutes for a response. Areas were searched up to three times, with at least a week between surveys to increase our chances of hearing owls if they were in the area.

All surveys were done from sunset to within 6 hours after sunset. More than 75 percent of the great gray owls were heard within 3 hours after sunset. On occasion, a great gray owl would call before sunset, but this was the exception rather than the rule.

We first heard great gray owls calling in late February and March, although the timing depended somewhat on elevation. The lower the elevation of the area, the earlier they called; for example, at the Spring study area (the lowest in elevation-930 to 1,140 meters), great gray owls started calling in late February and early March. At Bowman (the highest elevation-l,380 to 1,500 meters), the owls began calling in mid to late March.

When an owl was heard at night, we returned during the day to the exact spot and searched for whitewash (fecal material), pellets (regurgitated fur and bones), and nest platforms. We often found a nest within 30-250 meters of where we heard an owl calling at night. We think these birds defend only the immediate area around the nest site (Bull and Henjum 1987). Although concentrations of whitewash and pellets were found near nest sites, none were found under the actual nest until a week before the young left the nest. This nest sanitation probably reduces detection by mammalian predators using olfactory signals.

Nesting Biology

From 1982 to 1988, we observed 71 nesting attempts and recorded information on phenology (chronology of nesting) and reproduction at these nests (Bull and others 1989b). Courtship started in late February or March, depending on the study area, with both the male and female in the vicinity of the nest. Both birds called, the male giving a series of low whoos. The female more typically gave begging calls, particularly just before the onset of nesting. During courtship, the two birds preened each other and spent a great deal of time near the nest. Great gray owls do not build their own nest or even add material to an existing one. Thus their nesting is contingent upon the availability of a suitable nest platform.

During courtship the male presents the female with prey for her to consume. This prey provided by the male enables the female to acquire food without expending energy and thereby build her body reserves for egg production and incubation.

The female starts incubating after the first egg is laid; an egg is laid every 2-4 days. The male continues to bring prey, doing most of the hunting at night. By day, the male roosts in a tree close to the nest, often in a Douglas-fir, which provides shade as well as concealment from avian predators.

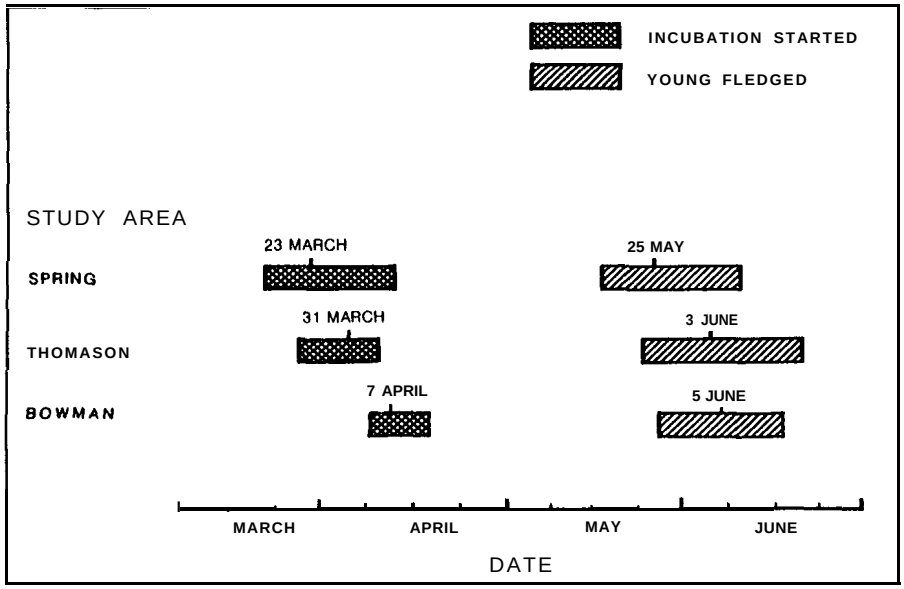


Figure 3-Phenology of great gray owls nesting in three study areas in northeastern Oregon, 1982-88.

The onset of incubation differed among study areas but not among years. It appears that nesting can be delayed when deep snow remains. Snow depth may be a chief determining factor for incubation. Owls in Spring went on nests about 7 days earlier than owls in Thomason and about 10 days earlier than owls in Bowman and Sheep (fig. 3). Females laid eggs from 17 March to 17 April. Once incubation began, females incubated the eggs almost constantly, leaving the nest once or twice during the night to regurgitate pellets and defecate. We observed only two females off their eggs during the day. Females diligently remained on the eggs, and we were careful not to disturb the birds at this time. It is essential that females remain on the eggs during the day, because unattended eggs are highly vulnerable to predation by ravens.

Eggs hatched at the same interval that they were laid. This sequence of hatching presumably has selective advantages if food is limited, because at least some of the young (the largest) may survive. Females ate the egg shells; we found egg shell fragments in pellets at 82 percent of the nests where we collected pellets. Males continued to supply the female and young with food, and females fed small bits of meat to the newly hatched young. Females constantly brooded the young. As the nestlings grew they were able to swallow larger pieces of meat. With the increased demand for food, males hunted during daylight hours in the morning and evening as well as at night.

After about 3 weeks, the female no longer brooded the young during the day but perched near the nest. After about 4 weeks, the young owls left the nest (color plate A). Assuming, incubation lasted 36 days, as reported by Mikkola (1983) in Finland, the mean number of days in the nest was 26 days. Young left the nest between 14 May and 19 June. Nestlings raised at Spring left the nest earlier than nestlings raised in the other study areas (fig. 3).

Seventy-eight percent of the nesting pairs successfully raised young. We observed 10 broods with 1 young, 20 broods with 2 young, 16 broods with 3 young, 1 brood with 4 young, and 1 brood with 5 young. We calculated a mean brood size of 2.2 by counting the number of young we saw in a nest within a week of fledging or by counting the number of young that had fledged.

The owlets in a nest fledged over several days, with the largest nestling usually the first to leave. We never observed all young in a nest leave on the same day. Five young in one nest left over 8 days. Weights of juveniles just out of the nest ranged from 360 to 755 grams.

After young left the nest, the female stayed near to protect them. Any intruder-person, beast, or bird-coming near the young was immediately warned by the angry hoots of the female. If her warning went unheeded and the intruder approached the young, the female frequently attacked. The male continued to feed both the female and young. After several days, the male usually took prey directly to the young, and the female caught her own prey. Some females also caught prey for the young. After 3 to 6 weeks, 11 of 12 females had apparently left the care of the young to the male; the females were at least 2 kilometers away, and we never saw them near the young again. One of these 12 females remained near the male and young for several months. Males continued to feed the young for up to 3 months after the young left the nest. After this time, the young started to catch prey on their own.

We found one exception to this pattern, when a female took over the care of the one young that survived. The two young that had been in the nest left the nest 30 days after hatching. Their weights were 360 and 530 grams, which were well below the average weight for young leaving the nest (609 grams). These low weights indicated that the young were not getting enough food. After leaving the nest, the smallest owlet died, probably of starvation. The male was alive and within 3.5 kilometers of the nest after the young left it, but he apparently quit feeding the female and young shortly before they left the nest. The female continued to feed the owlet for at least 2 months, and we never observed the male feeding them again.

We observed some unexpected behavior among several of the nesting birds. Twice, we observed adult owls favoring the weakest of the fledglings. One of three young that had just left the nest was blind in one eye and very uncoordinated. The female stayed nearest the blind owlet, and the male fed it more frequently than the others. In another case, one of two fledglings was temporarily injured by our handling and the female stayed with that owlet for several days until it could fly again. This behavior is contrary to some theories stating that the strongest young are favored and weaker ones allowed to die if resources are limited. In our observations, food resources probably were not limiting, and it would seem advantageous to help the weakest offspring so long as it did not jeopardize the survival of the others.

Another situation occurred when a young great gray owl out of the nest about 2 weeks was brought to us because its parents could not be located.-Rather than keep the bird in captivity, we hoped another great gray family group would adopt it. We released this orphan near another owlet of similar age. Within 2 days the male was feeding the orphan as well as his own young. This species apparently will accept and feed young belonging to other pairs. This behavior may have an adaptive advantage: if a male feeding fledged young dies, another male in close proximity may adopt the orphaned young owls and feed them along with his own. We think this phenomenon is possible because of the close proximity of some nests, and because we have observed different family group interacting occasionally.

Renesting Attempts

Some owls will try a second nesting attempt if the first one fails, but this depends on the condition of the female, prey supply, and time of year. We know of three females that renested after their first nesting attempt failed. During the first nesting attempt, two nests failed during incubation and one failed with nestlings; these females renested after 17-20, 28, and 30 days, respectively. In a fourth case, **a** nesting female failed during incubation, and a second female laid eggs on the abandoned nest 13-15 days after the first female left it. We do not know if both females were mated with the same male, because only one male was observed. Females that renested laid their second clutch between 25 April and 23 May. Two of the renesting attempts were successful, and young left the nest between 22 June and 18 July.

Nest Defense and Success

The adult owls readily defended their nests with **a** ferocity that discouraged most predators. We saw females pursue common ravens and red-tailed hawks on numerous occasions, and one female attacked and hit a coyote when it came near a nest of young. Females frequently attacked and hit us when we handled their young or climbed the nest tree. Aggressive behavior differed among individual birds and typically increased the more years we had worked with a particular bird. Although females were usually more aggressive than males, we observed two males that pursued ravens, **a** coyote, and a red-tailed hawk when they came near the nest.

In spite of aggressive nest defense, 22 percent of the nesting attempts failed. Of the nesting attempts that failed, 63 percent failed during incubation, 26 percent failed with nestlings, and 11 percent were unknown. Eggs apparently fell through two nests, and young fell out of three nests. Two females abandoned their eggs after incubating for 26 and 42 days. At the former of these nests, the male had apparently quit feeding the female, because we observed the male frequently catching and consuming prey. The cause of nest failure at 12 nests was unknown, although we suspect common ravens were the primary predator during incubation because (1) ravens frequently flew over the nests and even paused in midair directly over nests, (2) the owls reacted to the presence of ravens near the nest by hooting or pursuing them, (3) ravens mobbed a female on a nest, and (4) broken egg shells were found within 150 meters of four deserted nests.

Breeding Age

We followed nineteen l-year-old birds and three 2-year-old birds with transmitters, and none of them nested. One of these radio-tagged males courted a female during both his second and third year, but we never found them nesting. We also found a 2-year-old female and a 3-year-old male nesting that we had banded as young. The female nested 8.5 kilometers from her natal site, and the male nested 33 kilometers from his natal site. We suspect great gray owls rarely breed at 1 year, sometimes at 2 years, and more commonly at 3 years.

Breeding Pair Density

Great gray owls regularly nested in close proximity to other great gray owls, which supports the theory that they defend only the immediate nest site. The shortest distance between two active nests was 430 meters; two other nests were 460 meters apart. We calculated a density of nesting pairs of great gray owls in 1984 in portions of the Spring and Thomason study areas where we were reasonably certain we had found all nests. The highest densities at Spring and Thomason were 7 pairs per 9.4 square kilometers (entire study area was 44 square kilometers) and 5 pairs per 2.9 square kilometers (entire study area was 34 square kilometers), respectively. These are the highest nesting densities reported anywhere in the world for great gray owls.

Nest Site Fidelity

We observed 18 nesting attempts by nine pairs where at least one member of each pair was radio-tagged. Thirty-nine percent of these pairs nested on the same nest the second year, 39 percent nested within 1 kilometer of the previous years nest, and 22 percent nested more than 1 kilometer away from the previous years nest. The average distance between successive nest trees was 1.3 kilometers (range of 0.2 to 4.5 kilometers) (fig. 4). Four pairs nested more than 1 kilometers from the previous years nest, and each of their vacated nest sites was occupied by another pair of nesting great gray owls the next spring.

At least six pairs seemed to have at least one alternative nest platform. During the month before incubation started, these pairs perched near one nest platform for a time and then perched near the other platform, as though trying to decide where to settle.

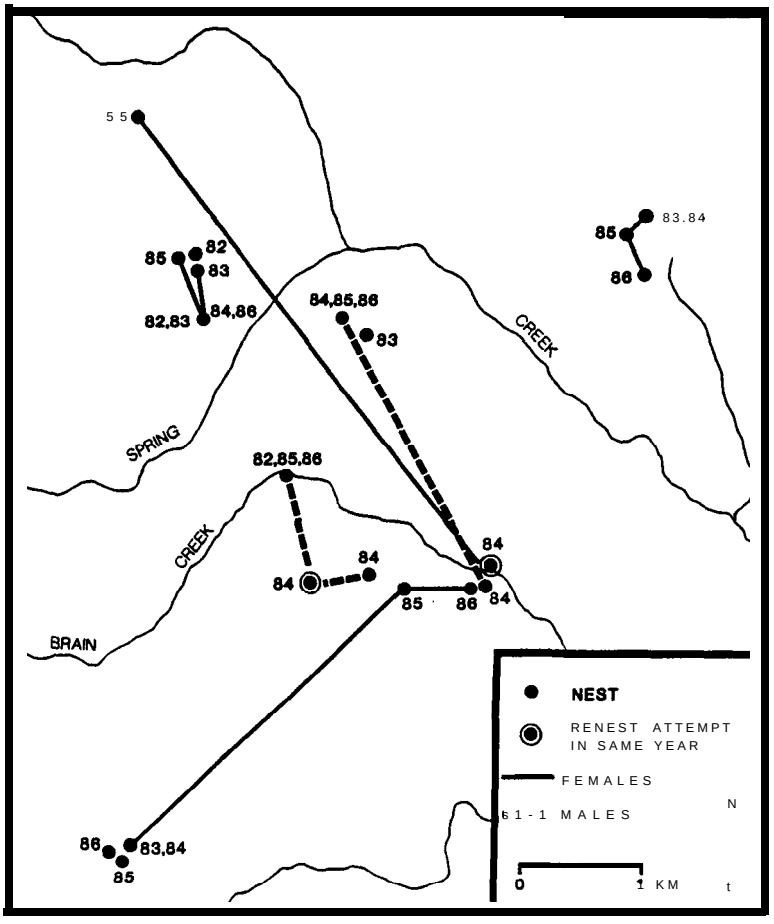


Figure 4-Location of nests of radio-tagged great gray owls in the Spring study area, 1982-88. Lines connect nests used in successive years by the same bird.

Diet

Prey Items in Pellets

The diet of great gray owls was determined from 1,923 pellets collected near 58 active nests (Bull and others 1989a). Most of the pellets were found under trees where females had perched and regurgitated pellets. We separated the bones out of the pellets and identified and quantified the skulls and jaw bones to determine prey species. From these pellets, we concluded that great gray owls preyed primarily on small mammals. The diet consisted of 15 species of small mammals, 4 individual birds, 1 fish, and 1 insect. By frequency, voles made up 52 percent of the prey, but northern pocket gophers made up 67 percent of the prey by biomass (tables 1 and 2). Of the voles, 59.5 percent, 6.6 percent, and 0.2 percent were mountain, longtail, and Richardson voles, respectively; 33.7 percent could not be identified to species.

Some variation in diet occurred among study areas. A higher percentage of redback voles was eaten in Bowman and Thomason (table 1). Owls at Thomason ate the highest percentage of northern pocket gophers. Owls at Sheep ate the lowest percentage of northern pocket gophers but ate more flying squirrels than in any other area. These differences in diet among study areas demonstrated the opportunistic nature of the great gray owl.

Table 1—Diet composition of great gray owls in northeastern Oregon, by study area, 1982-88[a]

Diet	Study area				
	Spring	Bowman	Thomason	Sheep	Total
	Percent				
Mammals:					
Vole[b]	67	34.4	39.9	67	51.6
Northern pocket gopher	26.7	32	30.6	22.8	28.8
Redback vole	2.3	21.6	24.2	2.5	13.9
Shrew[c]	1.7	2.8	2.4	3	2.2
Deer mouse	.7	.5	1.4		.9
Heather vole	tr[d]	6.4	0.2		.8
Yellow pine chipmunk	.8	.4	.7	.5	.7
Other mammals[e]	.6	1.6	.4	3	.7
Birds	tr	.2	.2	.5	.1
Fish			tr		tr
Insects	tr	.2	tr	.5	.1
Prey items (N)	2,086	566	1,697	197	4,546

[a] Determined from 1,923 pellets.
[b] Included mountain, longtail, and Richardson voles.
[c] Skulls that could be identified were vagrant shrew.
[d] tr equals <0.05 percent.
[e] Included prey comprising <0.3 percent of diet: northern flying squirrel, Pacific mole, red squirrel, bushytail woodrat, Columbian ground squirrel, and golden-mantled squirrel.

Table 2—Biomass of prey in the diet of great gray owls in northeastern Oregon, by study area, 1982-88

Diet	Weight[a]	Study area				
		Spring	Bowman	Thomason	Sheep	Total
	Grams	*Percent*				
Mammals:						
Vole[b]	26	35.3	16.8	22	36.3	27.4
Northern pocket gopher	115	60.6	69.1	74.6	54.7	67.3
Redback vole	19	.9	7.7	1	1	1.8
Northern flying squirrel	115	.3	1.5	.2	7.3	.7
Yellow pine chipmunk	56	1	.4	.8	.6	.8
Heather vole	27		3.2	.1		.5
Red squirrel	323	.7		.3		.4
Other mammals[c]		1.4	1.3	1	0.1	1.1

[a] Mean weight used for biomass calculations.
[b] Included mountain, longtail, and Richardson voles.
[c] Included prey comprising <0.3 percent of diet: deer mouse (16 grams), shrew (5 grams), Pacific mole (53 grams), bushytail woodrat (262 grams), Columbian ground squirrel (486 grams), and golden-mantled squirrel (164 grams).

Collins (1980) and Nero (1980) in Canada and Hoglund and Lansgren (1968), Mikkola (1972, 1981, 1983), Mikkola and Sulkava (1970), and Pulliainen and Loisa (1977) in Europe report that great gray owls prey mostly on small mammals, voles in particular. Pocket gophers seem to be eaten in greater numbers in northeastern Oregon and other parts of the Western United States than elsewhere in the range of the great gray owl.

Hunting Observations

We followed eight radio-tagged males during the nesting season for 229 hours to observe the prey they caught and determine if the prey we observed them capture corresponded with prey we found in the pellets. Ninety captures were observed. Rate of successful prey capture per observed attempt averaged 33 percent; the mean rate of successful capture ranged from 16 to 60 percent for individual owls. The prey captured was 74 percent voles, 19 percent mammals larger than voles, and 6 percent shrews; 28 items could not be identified. The prey larger than a vole consisted of northern pocket gophers, yellow pine chipmunks, and northern flying squirrels. Of the **prey** captured, 75 percent of the shrews were eaten by the males with 25 percent taken to the nest; 37 percent of the voles were eaten with 63 percent taken to the nest; and 8 percent of the larger mammals were eaten with 92 percent taken to the nest.

Males took a greater proportion of the larger prey to the nest and ate a greater proportion of the smaller prey. In this way, energy expenditure was minimized when males returned to the nest with larger prey items; more food energy was delivered with larger prey in fewer trips to and from the nest.

Because breeding male great gray owls consumed more of the smaller prey and took more of the larger prey to the nest, analyses of pellets at the nest site may be misleading. We compared the prey composition found in 710 pellets collected at the nests of the eight radio-tagged males with what we observed them catch. Pellet analysis revealed 79 percent voles, 20 percent mammals larger than voles, and 1 percent shrews. The diet based on pellet analysis therefore underestimated the number of small prey items and overestimated the number of larger prey items consumed by the pair during the nesting period. Analysis of pellets at the nest did represent the diet for the female and young.

We observed great gray owls eating birds on two occasions. The first was a female eating a northern flicker, picking meat off the carcass. The second was a male eating all the young in an American robin nest, swallowing each small, downy chick whole. This observation explained the constant mobbing great gray owls received from robins in May, June, and July.

Influence of Prey on Nesting

In Canada and Europe, populations of great gray owls regularly experience years when they do not breed, presumably in response to low prey numbers (Hilden and Helo 1981, Nero 1980, Pulliainen and Loisa 1977). Between 1982 and 1988, great gray owls in Union and Umatilla Counties nested every year except 1987, and great gray owls in Wallowa County nested every year except 1988. We have information on small mammal numbers in one study area (Spring) in Union County for 1985 and 1987 that suggests the lack of breeding corresponded with a crash in the number of voles and other prey species.

We sampled the small mammal population in the Spring study area in August 1985 and 1987 by trapping in 18 plots. At each plot, we used a 5-by-5 grid with stations at 5-meter spacings and set two museum specials and one rat trap at each station. We trapped for three nights at each plot for a total of 4,050 trap-nights each August.

A dramatic decrease occurred in the number of small mammals trapped from 1985 to 1987. We trapped 187 small mammals in 1985 and 23 in 1987-on the same plots, at the same time of year with trapping done in the same manner. In 1985 and 1987, the respective numbers trapped were 107 and 0 voles, 23 and 3 redback voles, 22 and 13 deer mice, 20 and 6 yellow pine chipmunks, 8 and 0 northern pocket gophers, 6 and 1 shrews, and 1 and 0 bushytail woodrats.

We think the absence of voles and the decrease in other small mammal populations explained why none of the owls nested in the Spring study area in 1987. We have no small mammal data for Umatilla or Wallowa Counties, so do not know what occurred there. Because there was evidence from sightings, feathers, pellets, and whitewash of great gray owls in Spring in April 1987, we believe that the birds were there but did not nest and did not go elsewhere to nest. There simply was not enough prey for the birds to raise young.

Habitat

Nesting Habitat

Because great gray owls do not build their own nests, they must use existing platforms. From 1982 to 1988, we located 49 nests used by great gray owls. The same nest was often used more than once: one nest was used for 4 years, six nests were used for 3 years, nine nests were used for 2 years, and two nests were used twice in the same year. Fifty-one percent of the nests were stick platforms, 29 percent were artificial wooden platforms, and 20 percent were natural depressions on broken-topped dead trees (table 3, color plates B-D). Of the stick nests, 68 percent were originally made by northern goshawks, 12 percent were made by red-tailed hawks, and 20 percent were natural platforms formed by dwarf-mistletoe brooms (fig. 5).

The owls seemed to use whatever type of platform was available in each study area; for example, 72 percent of the nests in Spring and Sheep were on stick nests. Stick nests were common in these areas, but large-diameter dead trees were scarce, and there was only one artificial platform before 1985. At Thomason, where there were 38 artificial platforms available and an abundance of large-diameter, dead trees, all but one of the nests were on broken-topped dead trees or artificial platforms. Stick nests were uncommon in this study area.

If there was **a** preference for nest type, we think the owls favored artificial platforms, perhaps because they were more stable than stick ones. These platforms were readily used, even when there were natural stick platforms in the immediate vicinity. In addition, the rate of successful nesting attempts was higher on artificial platforms (83 percent) than on stick platforms (66 percent). Eggs or young fell through at least three stick nests, and 36 percent of the stick nests disintegrated within a year.

Table 3—Characteristics of 3 types of great gray owl nest structures at 49 nest sites in northeastern Oregon, 1982-88

Characteristic	Nest structure					
	Stick		Broken-topped tree		Artificial platform	
Number of nests:						
Spring	16		1		6	
Bowman	3		2		3	
Sheep	5		1		—	
Thomason	1		6		5	
	Percent					
Nest tree species:						
Western larch	76		10		43	
Douglas-fir	20		20		—	
Ponderosa pine	4		70		43	
Lodgepole pine	—		—		14	
	x	*SD*	*x*	*SD*	*x*	*SD*
Nest height (m)	17	5.05	11	3.88	12	3.01
Tree d.b.h. (cm)	58	17.16	78	15.24	58	17.20
Tree height (m)	30	4.98	11	3.65	29	8.73
Bole height (m)	10	5.00	8	4.24	13	6.59
Tree age (years)	151	35.07	173	25.40	129	51.73

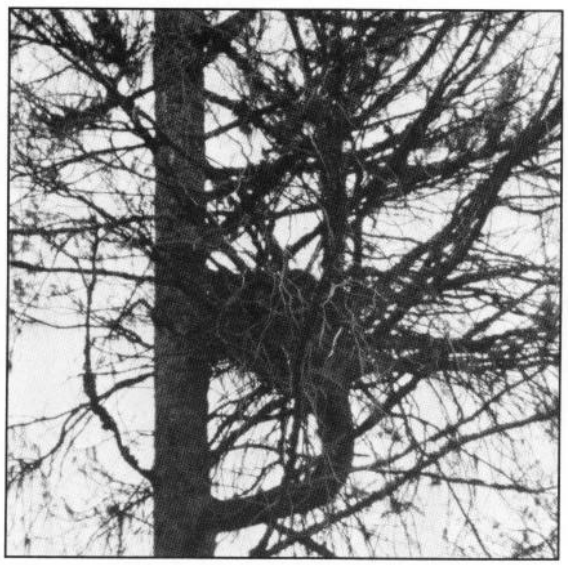


Figure 5—Great gray owl nest on a dwarf-mistletoe broom.

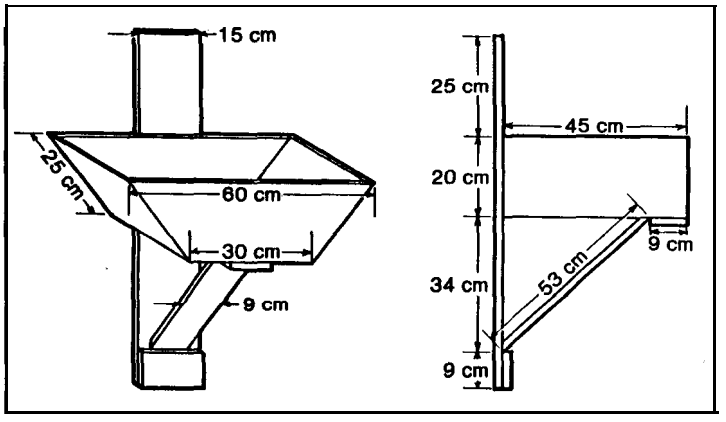


Figure 6--Great gray owl nest platform constructed from 2.5centimeter-thick boards. Platforms were stained with five parts linseed oil and one part gray stain.

Because great gray owls readily used artificial platforms (Bohm 1985, Bull and others 1987, Nero 1982), we decided to see if the owls showed preferences for type and location of these platforms. We put up 158 artificial platforms to determine preference for platform type (open platforms versus nest box), for height off the ground (9 versus 15 meters), and for proximity to a clearcut (adjacent versus 100-200 meters away). Great gray owls always nested on the open platforms (design shown in fig. 6), never in the nest boxes. Given a choice, the owls always used the platform 15 meters above the ground but used platforms 9 meters above the ground if none higher were available. Given a choice between a platform adjacent to a clearcut versus one 100 to 200 meters away in a forested stand, 80 percent of the owls (N = 5 nests) nested on the platform in the forested stand.

There was great variability in the type of nest as well as the type of stand used for nesting. Because these owls do not build their own nests, the nest location really reflected the choice of the nest builder, the branch structure of the tree, or the choice of whoever put up the artificial platform. Most of the stick nests were in large-diameter western larch, because these trees provided heavy branches capable of supporting a nest structure built by northern goshawks or red-tailed hawks. These stick nests used by great gray owls were fairly large and averaged 74 centimeters long, 65 centimeters wide, and 27 centimeters high. In contrast, most nests on broken-topped trees were in dead ponderosa pine, 46-94 centimeters in diameter at breast height (d.b.h.), and 6-18 meters tall. The trees chosen for nests were large in diameter because the top had to be wide enough to accomodate a family of owls. One of these nest depressions was 56 centimeters in diameter and 26 centimeters deep. These dead trees also had partially decayed wood at the top where the female could scratch out a depression for the eggs.

The habitat surrounding nest trees differed greatly (color plates E-G), and we found nests in the four forest types that we searched. Fifty percent of the nests were in Douglas-fir/grand fir forest types, 29 percent in lodgepole pine/western larch, 15 percent in ponderosa pine/Douglas-fir, and 7 percent in ponderosa pine. The majority (74 percent) of the nests occurred in stands with trees greater than 49 centimeters d.b.h.; 26 percent occurred in stands with trees 30-49 centimeters d.b.h.; and none occurred in stands of trees less than 30 centimeters d.b.h.

Most (72 percent) of the nests were in unlogged stands, while 19 percent were in stands with a partial removal of the overstory, and 9 percent were within 200 meters of a clearcut. This suggests that the owls favored unlogged stands, because 60-80 percent of the stands in each study area had been logged; however, we do not know if this reflected actual preference or the availability of nest sites. We think most goshawk nests and large-diameter dead trees occurred in unlogged stands because logging activity typically eliminates both.

Forty-seven of the 49 nest sites had two or more canopy layers with a canopy closure in excess of 60 percent at most nests. Western larch comprised the dominant crown class at 50 percent of the nest sites. Density of live trees l0-49 centimeters d.b.h. ranged from 5 to 64 stems/0.1 hectare, and live trees greater than 49 centimeters d.b.h. ranged from 0 to 10 stems/0.1 hectare.

Sixty-nine percent of the nests occurred on slopes, 22 percent on flat ground, and 9 percent in draws. Nest sites on slopes were in areas having a fairly gentle slope (averaged 13 percent slope gradient). Most of the nests (65 percent) occurred on north-facing slopes; however, these slopes usually contained denser stands than south slopes and were preferred nesting habitat of the northern goshawk (Reynolds and others 1982), the primary builder of nests used by great gray owls.

The percentage of area in forest within a 500-meter radius of each nest ranged from 52 to 99 percent, and the percentage of that forested area that had been logged ranged from 0 to 97 percent.

Perches Used by Nesting Females

Females with eggs or small young left the nest infrequently to defecate and regurgitate pellets. If we found a perch with a large accumulation of pellets, it was very likely that there was a nest nearby. One or several perches 30-200 meters from the nest were used repeatedly for this function (color plate H). If several perches were used, they were usually in the same general vicinity and often in a straight line away from the nest. Perches were usually uphill or on the same contour as the nest, presumably so the female could watch the nest and return to it quickly if necessary.

Females perched on branches (61 percent), leaning trees (26 percent), and broken-topped dead trees (13 percent). Branches used as perches were usually dead limbs in a large-diameter ponderosa pine; leaning trees used as perches were generally small-diameter western larch or lodgepole pine. Perches were typically close to the ground (most were less than 6 meters above the ground) in sites with a relatively open understory to facilitate easy and fast maneuvering, yet with a fairly dense canopy closure (average of 59 percent) overhead to provide cover.

Perches Used by Juveniles

Owlets left the nest before they could fly but were capable climbers; they used talons, bill, and wings to claw and flap their way up tree trunks. For the first few days, leaning trees with bark were easiest for the young to climb to get off the ground and away from terrestrial predators (color plate I). After several days, juveniles could climb some vertical trees, particularly those with branches or deeply fissured bark because the bark provided a gripping surface for the owlets. After leaving the nest, juveniles invariably headed for dense forest cover (color plate J), if the nest was not already in such cover. As the owlets aged, they perched higher in the canopy and thus had more cover and shade.

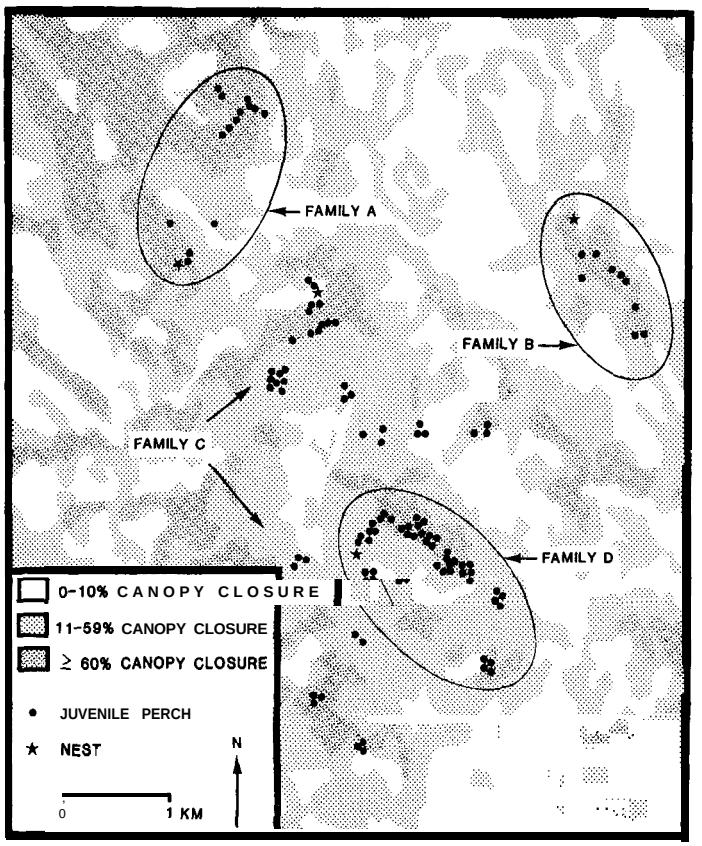


Figure 7-Location of nests and perches used by juveniles of four great gray owl family groups in Spring study area. Juveniles were located during the first 2 months after fledging. Family groups A and B nested in 1983, and family groups C and D nested in 1985.

Within the first week after fledging, all the juveniles stayed within 200 meters of the nest. Sixty-seven percent of the perches they used were either leaning trees or trees touched by a leaning tree that the owlets crawled up in order to get to the perch. Leaning trees used as perches were typically small-diameter, dead lodgepole pine or ponderosa pine with an average of 87 percent of the bark remaining. The branch perches were generally in live Douglas-fir with branches within 0.5 meter of the ground.

Within 2 weeks after leaving the nest, juveniles could fly, thus increasing their mobility; however, owlets generally restricted their movements to forests having at least 60 percent canopy closure (fig. 7). We think the owlets remained in these dense stands because of the cover provided against avian predation.

Foraging Habitat

Great gray owls usually hunted from perches close to the ground. They flew from perch to perch, listening and watching the ground intently. Even after hearing something, they would often listen or watch for several minutes before attacking. The average distance from the perch to the prey was 10.5 meters. If they did not catch prey, they usually flew to a perch quickly. If they caught prey, they often remained on the ground for several minutes and eventually swallowed the prey or carried it to the nest. If the prey captured was as large as a woodrat or flying squirrel, they flew to a perch and picked meat off the carcass. The great gray owls we observed usually hunted in forested stands having an open understory, thus enabling them to fly without maneuvering around trees. Most of the stands had been logged, thereby leaving an open stand of trees with a dense cover of grass on the ground (color plate K).

We followed eight male great gray owls (with radio transmitters) for 229 hours during daylight hours while they were foraging, and we recorded habitat characteristics of the areas used for hunting (Bull and others 1988b). The males hunted from perches averaging 5.5 meters aboveground. At sites where the owls either caught prey or attempted to catch prey, vegetative cover averaged 88 percent with a mean height of 21 centimeters; grasses dominated (color plate L). At 77 percent of the sites, downed wood was within 1 meter of the point of capture (color plate M). This downed wood presumably provided cover for small mammals.

For five of the eight radio-tagged males, we compared habitat they used with expected use based on availability. Males preferentially foraged in stands with 11-59 percent canopy closure and avoided clearings. Four of the males avoided stands with at least 60 percent canopy closure; one male used such stands in proportion to their occurrence. Use of edge was greater than expected with two males (color plate L), less than expected with two males, and no different than expected with one male. This variability again reflects the opportunistic nature of the species; they go where the prey is.

There were differences in habitat used between five foraging males at Spring and three at Sheep and Bowman (table 4). Males at Spring hunted more often in open, logged stands with one or two canopy layers and containing more ponderosa pine (fig. 8). Males at Sheep and Bowman hunted more often in stands that were unlogged with two or three canopy layers and containing more Douglas-fir and lodgepole pine (fig. 9).

Maximum distances from the nest that the eight radio-tagged males foraged ranged from 0.7 to 3.2 kilometers. The home range of five males (with more than 90 location points) during the nesting season averaged 4.5 square kilometers (range, 1.3 to 6.5 square kilometers). The home range was calculated by connecting the outermost points of observation and determining the area of the polygon (minimum convex polygon method).

The areas used by several males for foraging overlapped. We observed three instances of males hunting within sight of each other with no aggressive behavior exhibited. The occurrence **of** shared hunting grounds supports the theory that pairs defend only the immediate nest site. This behavior is unlike that of many owl species that defend their entire territory all year to ensure that other owls of the same species do not hunt in the same area (Mikkola 1983).

Table 4-Characteristics of foraging sites of 8 nesting male great gray owls in northeastern Oregon, 1985

Characteristic	Spring (N=357)	Sheep/Bowmar[a] (N=265)
	Percent	
Forest type:		
Ponderosa pine	62	3
Ponderosa pine-Douglas-fir	25	5
Douglas-fir-grand fir	11	60
Lodgepole pine-western larch	2	32
Successional stage:		
Subclimax	23	17
Mature	61	58
Over-mature	6	6
Remnant	10	19
Physiognomy of stand:		
Open forest	84	51
Edge	14	30
Dense forest	2	19
Logging status:		
Unlogged	25	**49**
Partial cut	74	46
Clearcut	1	5
Number of stand layers:		
1	46	13
2	52	54
3	2	33
Perch location:		
Branch	68	55
Trunk	27	25
Leaning tree	5	20
Tree species of perch:		
Ponderosa pine	82	7
Lodgepole pine	9	55
Douglas-fir	7	25
Other	2	13

[a] The 3 birds in Sheep and Bowman were combined because of the small sample size.

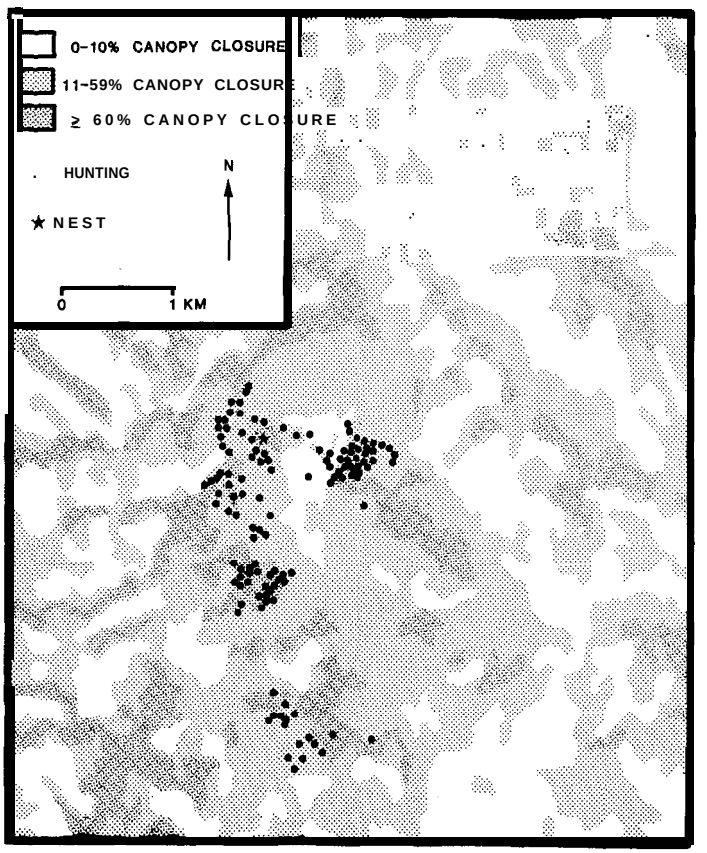


Figure 8—Locations at 15-minute intervals of a hunting male great gray owl in the Spring study area during daylight. Observations were made on 10 days between 1 April and 22 July 1985.

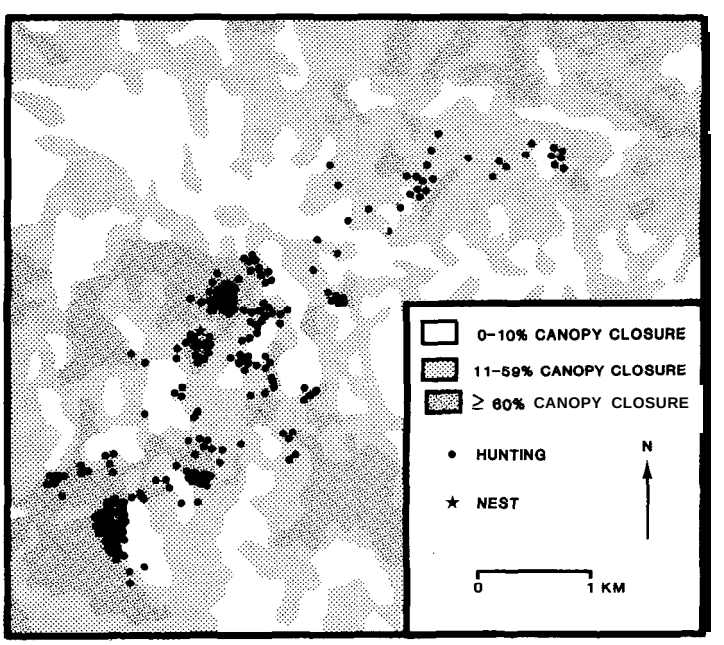
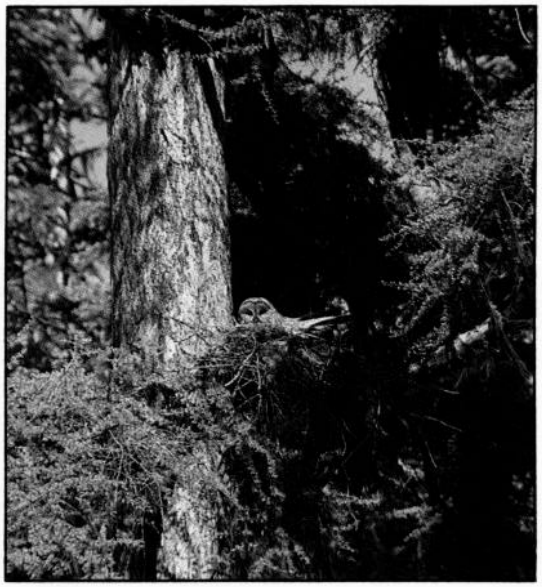


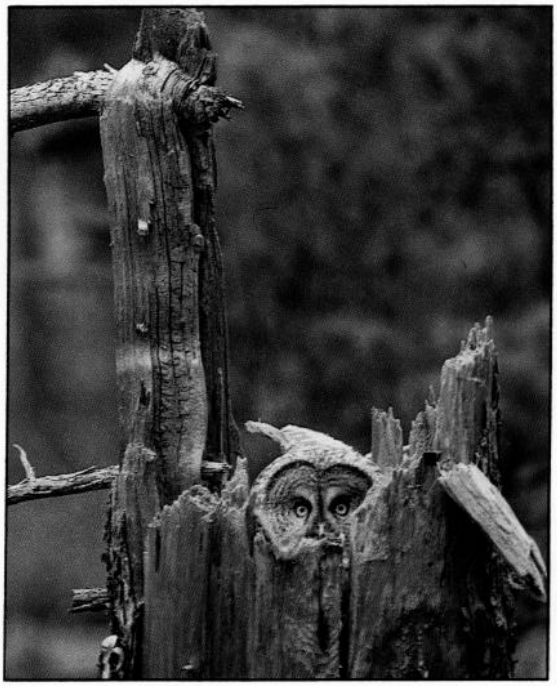
Figure 9—Points of observation at 15-minute intervals of a male great gray owl in the Sheep study area during daylight hours. Observations were made on 14 days between 13 May and 26 June 1985.

Color plate A—Juvenile great gray owls can be identified by their fluffy gray plumage, yellow eyes, large size, and lack of ear tufts.



Color plate B—Great gray owl nesting on vacated northern goshawk nest in western larch tree.

Color plate C—Great gray owl nesting on artificial platform.



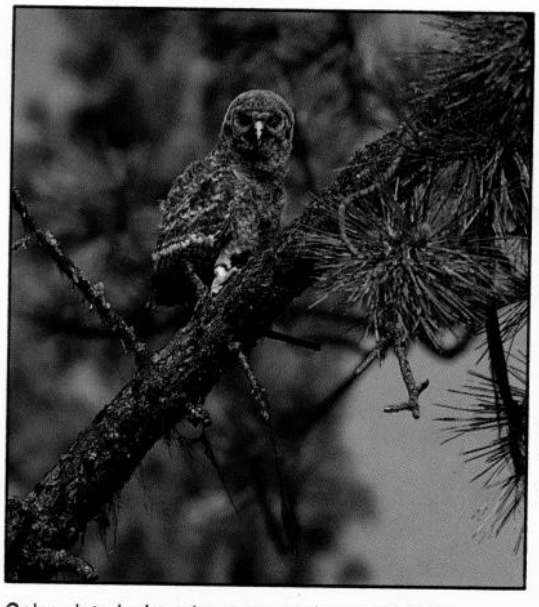
Color plate D—Female great gray owl sitting on nest on top of dead tree.

Color plate E—Unlogged, old growth stand surrounding great gray owl nest.

Color plate F— Partially logged stand containing a great gray owl nest.

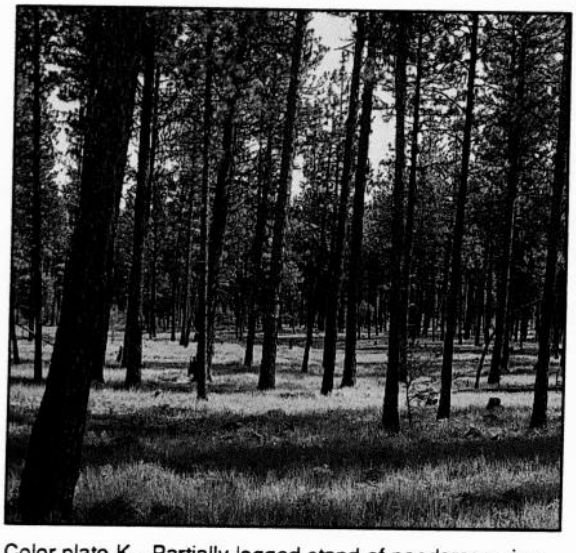
Color plate H—Leaning tree used for a perch by the nesting female for regurgitating pellets and defecating.

Color plate G—Great gray owl nest adjacent to small clearcut.

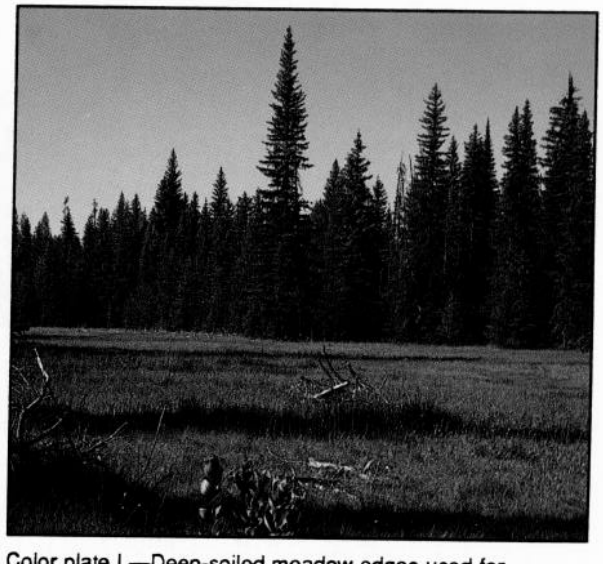


Color plate I—Leaning tree used as a perch by juvenile great gray owl just out of the nest and unable to fly.

Color plate J—Forest stand with closed canopy and leaning trees used by juveniles for several weeks after they leave the nest.



Color plate K—Partially logged stand of ponderosa pine used for foraging in the Spring study area.



Color plate L—Deep-soiled meadow edges used for foraging in the Bowman study area.

Color plate M—Prey were often captured in areas with a dominant grass cover and abundant downed material.

Color plate N—Great gray owl caught on a bal-chatri.

After foraging in the morning, the males roosted during the day in stands with 11-59 percent canopy closure (71 percent of the males) or denser (29 percent of the males). These stands typically had two or more canopy layers, were unlogged, and were mature or older. Owls roosted at least 7 meters above the ground 56 percent of the time, 3-7 meters above the ground 38 percent of the time, and below 3 meters 6 percent of the time.

Movements

Movements of Adults

We wanted to determine where great gray owls went when not breeding. To monitor owl movements, we attached radio transmitters to 10 males and 13 females and replaced the transmitters each year when possible (Bull and others 1988a). Birds were located from the ground every 2-3 weeks and locations marked on aerial photographs. We followed 3 owls for 3 years, 7 owls for 2 years, and 13 owls for 1 year. The recorded locations comprised the owls' home ranges, which were calculated by connecting the outermost points of observations and determining the area inside the polygon (minimum convex polygon method).

From 1983 to 1986, the maximum distance adults traveled from nest sites averaged 13.4 kilometers (range, 2.4-43.2 kilometers), and home range size averaged 67.3 square kilometers (range, 4-312 square kilometers). Adult owls from Bowman and Sheep traveled farther than owls from Spring (figs. 10 and 11). Average distance traveled from the nest and home range were 22.3 kilometers and 78.7 square kilometers (N = 3) from Bowman and Sheep and 11.3 kilometers and 8 square kilometers (N = 10) from Spring. We think this difference in adult movements was largely due to snow depths, because none of the birds wintered at Bowman where snow depths were 70-90 centimeters. Birds from Bowman moved to areas with shallower snow, except one female located for two winters in an area 43 kilometers from Bowman that had more than 150 centimeters of snow. In contrast, 6 of 13 adults remained in Spring for at least one winter, where snow depths averaged less than 50 centimeters. The seven adults that left Spring in winter went to areas with a mean snow depth of 24 centimeters.

The majority of the owls either stayed in areas with less snow or traveled to areas with less snow, presumably because of prey availability. We think deep snow made prey less available, because these birds plunge through snow to capture prey on the ground surface (fig. 12). The fact that one female spent two winters in an area with 150 centimeters of snow suggests that at least some birds can survive in areas with deep snow. We think this female was preying on squirrels, hares, rabbits, and birds, because small mammals beneath the snow were probably not accessible.

Of eight adults followed two or more winters, six returned to the same area or even the same stand for at least a portion of more than one winter. But considerable differences occurred in movements and home range size among birds and even between years for the same bird (table 5). Pairs did not stay together during nonbreeding periods; however, pairs did return to the same area to nest.

Much greater movements have been reported for the great gray owl in Canada and Scandinavia than we observed (Mikkola 1981, Nero and Copland 1981, Oeming 1964). We think the relatively short distances we observed the birds traveling were a function of topography. Owls had to travel only a short distance to change elevation, snow depth, and probable availability of prey. Owls in Ontario, Manitoba, and Minnesota must travel long distances to change elevation and snow depth.

During the winter, 11 juveniles from Bowman and Sheep moved to areas with fess snow accumulation (fig. 13); 12 of 14 juveniles from Spring spent most of their first winter 6-13 kilometers to the east in an area characterized by open ponderosa pine stands (fig. 14). One juvenile spent the winter in Spring, and another went 6 kilometers north of Spring to an area being logged. We were surprised to find this owl adjacent to active logging operations, but tree falling and soil disturbance may have displaced many small mammals, thereby making them easy prey. Both this juvenile and an adult female in another winter remained close to logging operations; as the logging operations moved to different stands, the owls followed.

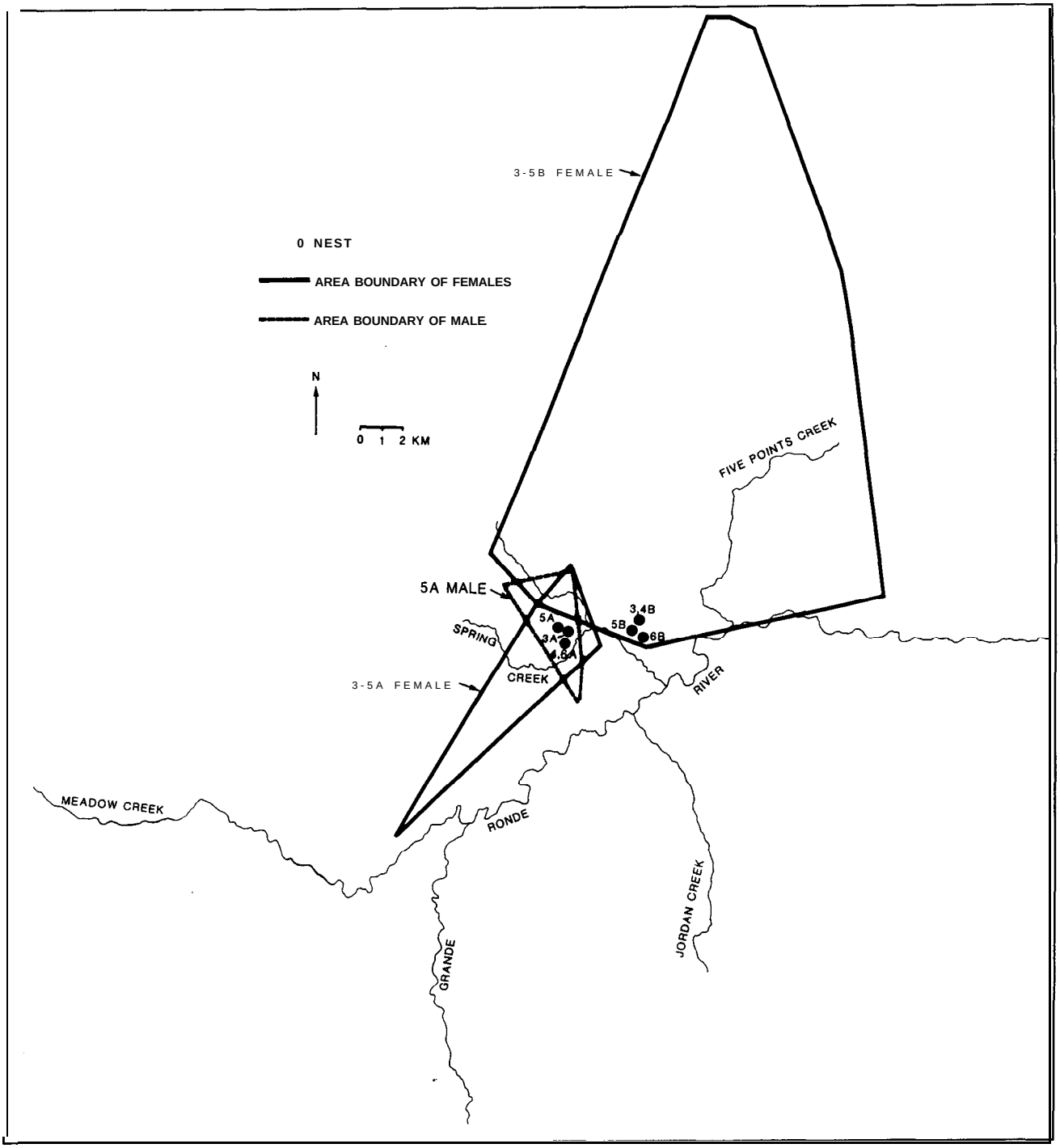


Figure l0-Area where three adult great gray owls were located in the Spring study area. A letter refers to a particular bird or pair; numbers preceding a letter refer to the years that bird was located (3 = 1983, 4 = 1984, 5 = 1985. and 6 = 1986). A letter preceding a dot (nest site) refers to the bird that nested there, and the number preceding it refers to the year that nest was used. Number of locations was 38 for 5A male, 70 for 3-5A female, and 40 for 3-5B female.

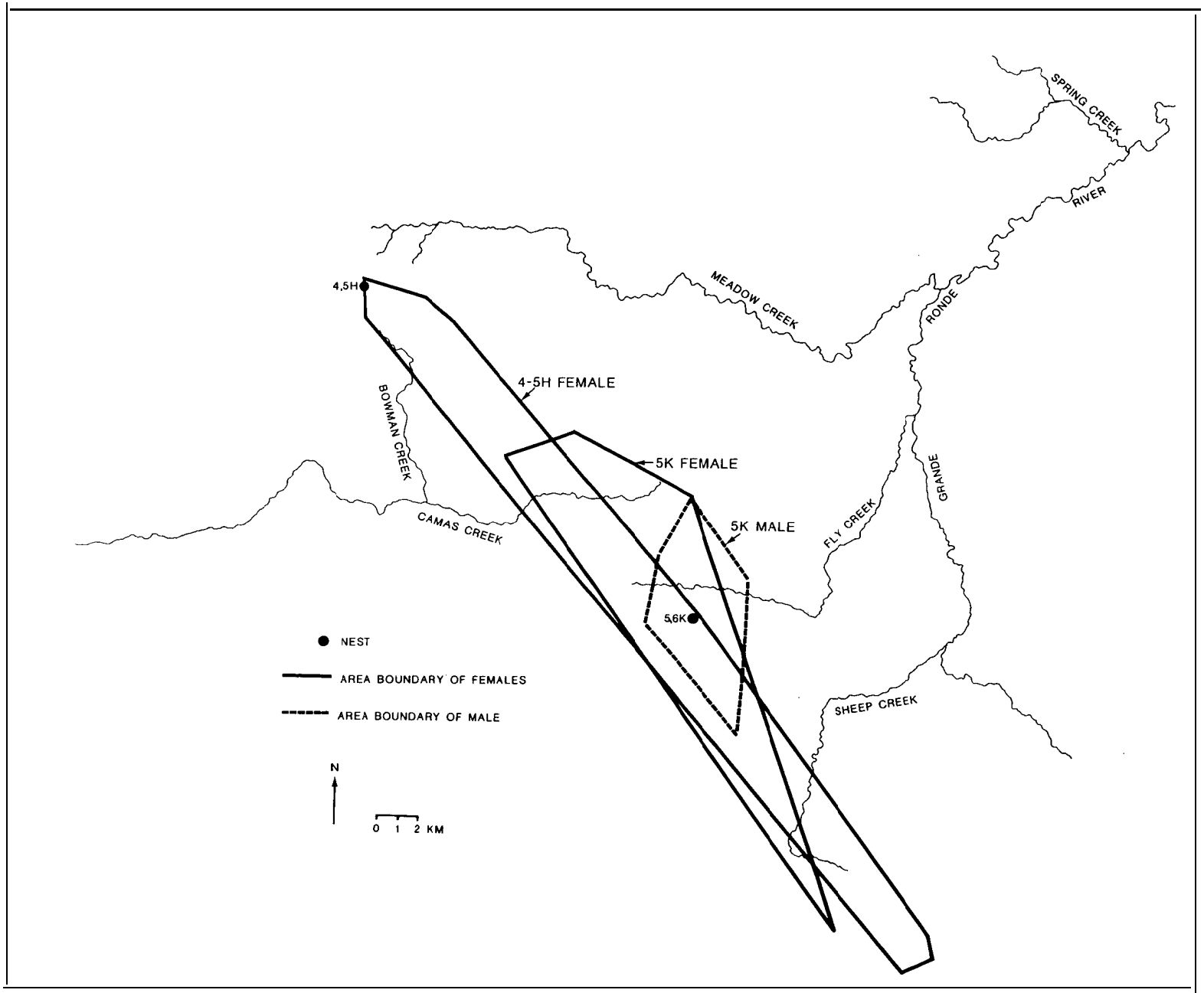


Figure 11—Area where three adult great gray owls were located in the Sheep and Bowman study areas. A letter refers to a particular bird or pair; numbers preceding a letter refer to the years that bird was located (3 = 1983, 4 = 1984, 5 = 1985, and 6 = 1986). A letter preceding a dot (nest site) refers to the bird that nested there, and the number preceding it refers to the year that nest was used. Number of locations was 26 for 4-5H female, 20 for 5K female, and 20 for 5K male.

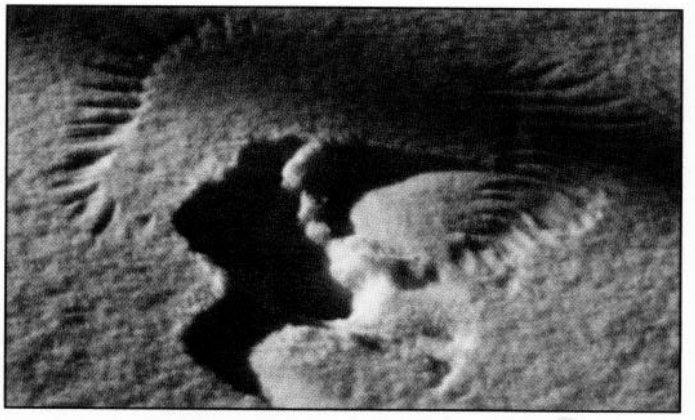


Figure 12—Plunge hole where an adult great gray owl caught a vole under the snow.

Table 5—Maximum distance traveled and home range size of radio-tagged adult great gray owls in northeastern Oregon

		1983-84		1984-85		1985-86	
Bird	N[a]	Distance	Area	Distance	Area	Distance	Area
		km	*km²*	*km*	*km²*	*km*	*km²*
Female A	72	2.9	4	12.5	18	2.4	5
Female B	40	6.9	10	28.2	151	18.7	115
Female D	89	18	135	17	43	10.4	26
Female C	42			8.2	27	6.7	16
Female H	27			41.2	91	43.2	68
Mean		9.3	49.7	21.4	66	16.3	46
Male C	60	22.8	37	19.2	120		
Male F	35			1.6	2	2.4	2
Male G	38			12.3	84	2.4	2
Mean				11	68.7		

[a] Number of locations.

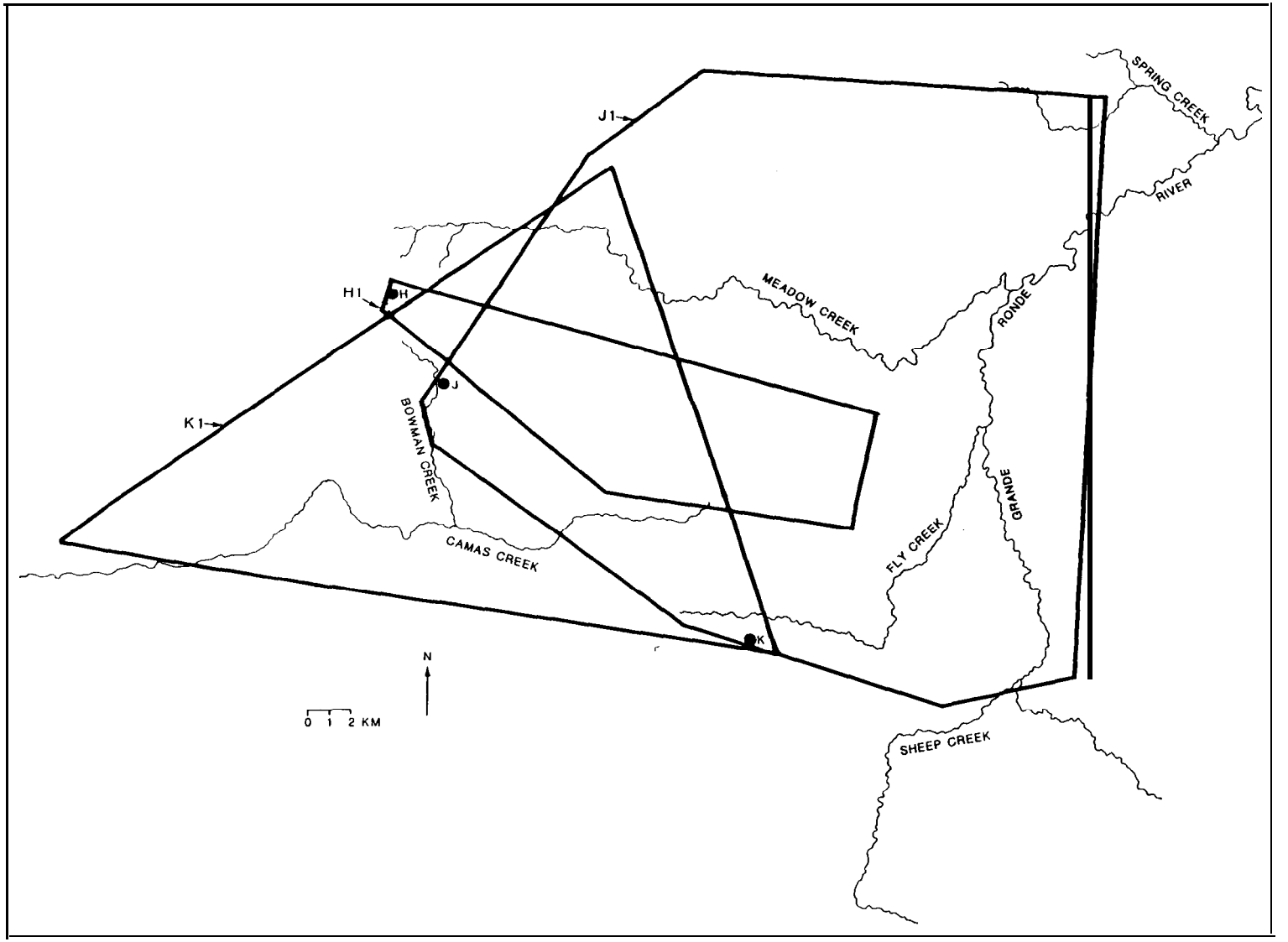


Figure 13-Area where three juvenile great gray owls from the Sheep and Bowman study areas were located from August 1985 until June 1986. A dot with a letter refers to a nest site. A letter with a number points to the area used by each juvenile raised at the nest with the corresponding letter. Number of locations ranged from 9 to 20 for each bird.

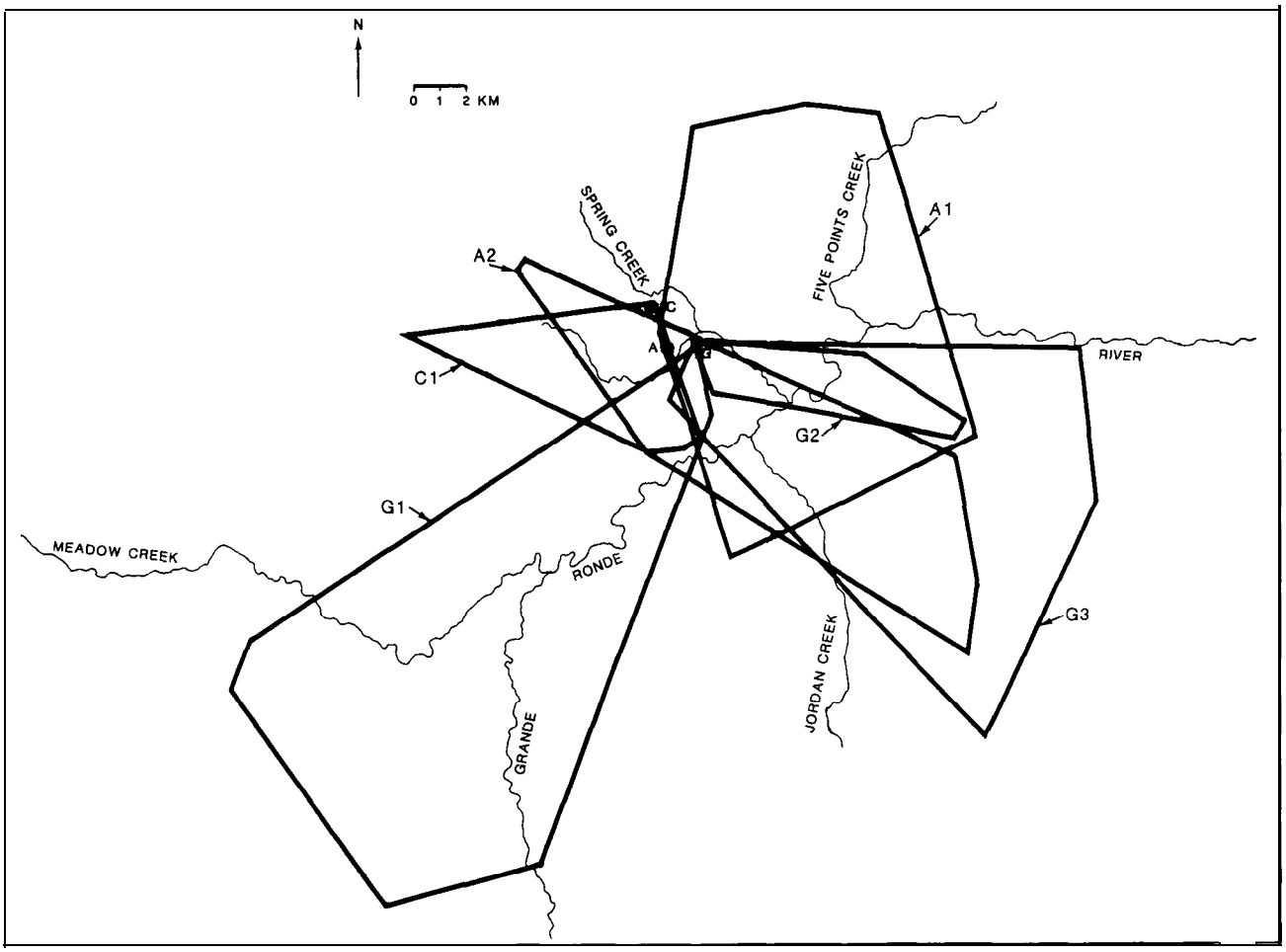


Figure 14-Area where six juvenile great gray owls from the Spring study area were located from August 1985 until June 1986. A dot with a letter refers to a nest site. A letter with a number points to each juvenile raised at the nest with the corresponding letter. Number of locations ranged from 12 to 21 for each bird.

Dispersal of Juveniles

To determine the dispersal of juveniles, we attached transmitters to 32 juvenile owls after fledging and located them every 2-3 weeks for a year. Data on 15 of them have not been included because 11 died within 6 months and 4 were located less than 10 times. We labeled these movements "dispersal" because they were movements of the juveniles away from natal sites.

Maximum distance 17 juveniles traveled from natal sites in their first year averaged 18.5 kilometers (range, 7.5-32 kilometers); home range size averaged 157 square kilometers (range, 20-637 square kilometers). Juveniles from Bowman and Sheep dispersed farther than juveniles from Spring. Mean dispersal distance from Bowman and Sheep was 29 kilometers; from Spring, it was 16 kilometers.

Dispersal of 2-Year-Old Birds

We followed one female and two male juveniles for 2 years. These birds had a larger home range their first year (mean, 167 square kilometers; range, 23-245 square kilometers), then restricted their movements to a smaller area the second year (mean, 13 square kilometers; range, 6-22 square kilometers) (figs. 15 and 16). These birds seemed to spend their first year traveling and then settled down in one area their second year.

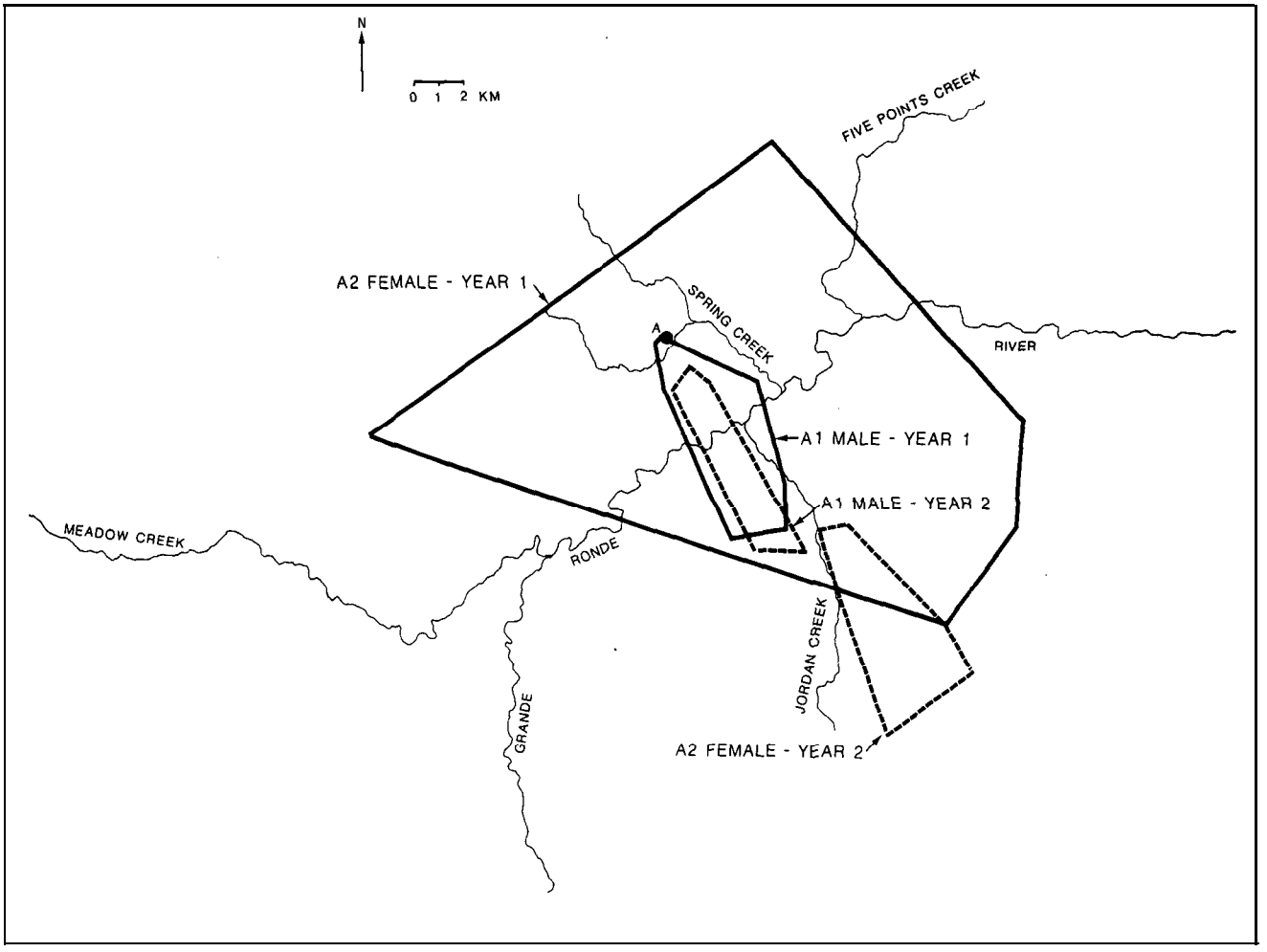


Figure 15-Area where two juvenile great gray owls from the Spring study area were located from August 1984 until June 1986. Their natal site was at A.

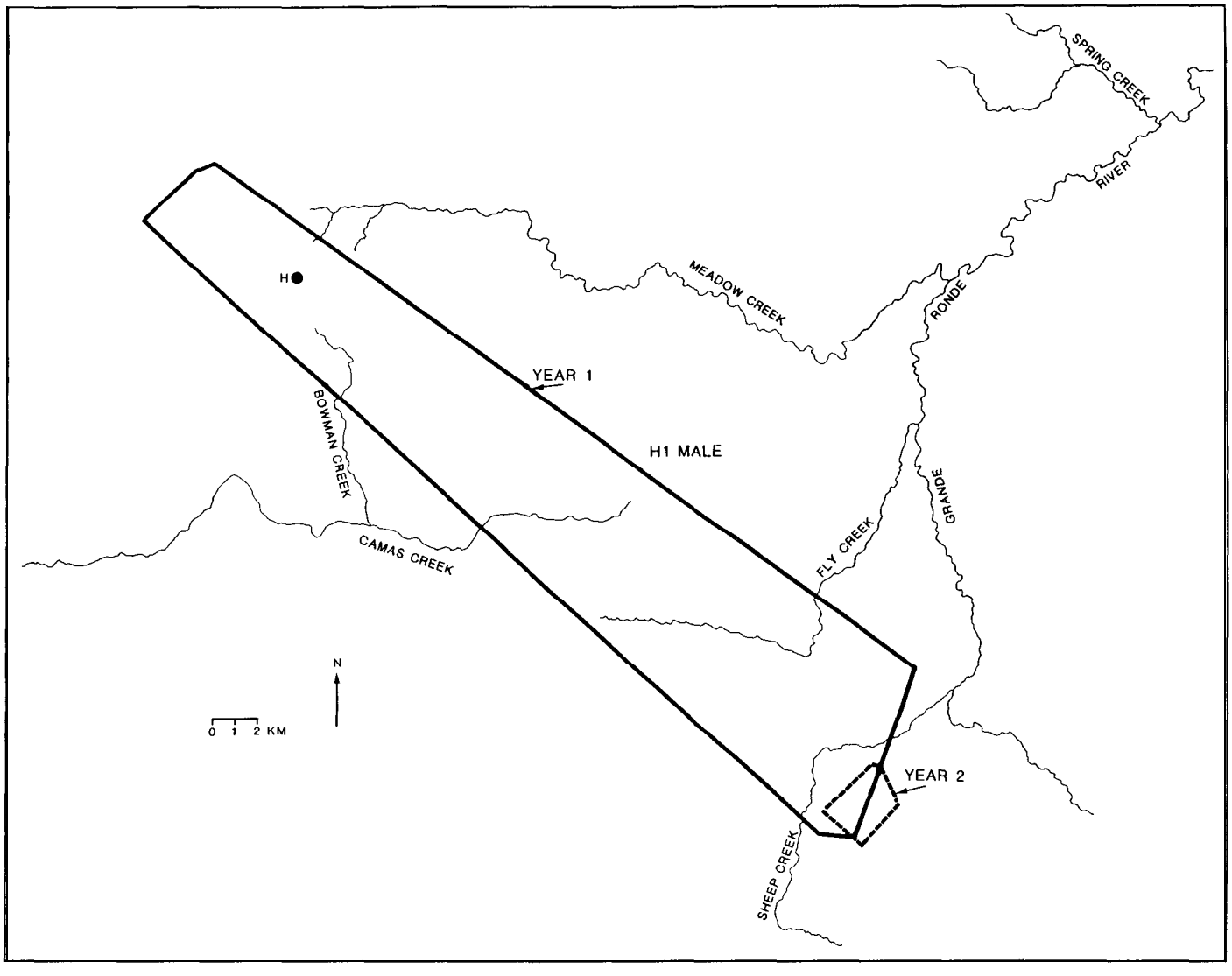


Figure 16--Area where one male juvenile great gray owl from the Bowman study area was located from August 1984 until May 1986. His natal site was at H, and there were 34 locations.

Mortality

During the 3 years when we had adults radio-tagged, 1 of 10 males and 3 of 13 females died. The annual probabilities of survival (Mayfield 1975) for adult nesting males and females were 0.91 and 0.84, respectively. All deaths occurred in fall or winter. Cause of death could not be conclusively determined.

Of 32 juveniles with transmitters, nine died before they became independent of the adults, five died in the fall, and one died after it was a year old. The probabilities of a juvenile surviving 12, 18, and 24 months are 0.53, 0.39, and 0.31, respectively. We concluded, based on plucked feathers and fecal material at the kill site, that great horned owls and northern goshawks killed seven of the dependent juveniles. We also saw a great horned owl fly from a tree containing the carcass of a dead juvenile. Two juveniles apparently starved to death while the parents were still feeding them. We

saw red-tailed hawks hit juveniles on two occasions. One of the juveniles was carried a short distance before it was dropped unharmed. Of the five independent juveniles that died, two died of avian predation and three of unknown causes.

The high rate of juvenile mortality observed in this study seems to agree with data on great gray owls in Canada and Finland (Mikkola 1981, Nero and Copland 1981). If juveniles survive to breeding age, survival rates are then quite high.

Trapping and Radio-Tagging Owls

Trapping **Techniques**

We used eight different traps to catch great gray owls (Bull 1987). The variety was necessary because these owls were extremely wary and were rarely caught by the same trap twice. To further complicate matters, the owls we dealt with seldom seemed to be stressed for food. Starving birds are much more likely than satiated ones to hit a trap with prey.

Initially we used a bal-chatri to catch great gray owls (color plate N). This large dome-shaped wire mesh cage (15 centimeters high) with a rectangular frame base (45 by 25 centimeters) was made of re-bar to add weight so that the owl could move the trap but not fly off with it. We attached 50-75 slip-nooses (6-10 centimeters in diameter) made from 18-kilograms monofilament line to the bal-chatri. We put two gerbils in the bal-chatri for bait, because two moved around more than one. The owls seemed to prefer gerbils, although we tried domestic mice, deer mice, and voles for bait.

Bal-chatris were easy to use, very portable, and safe for the bird. If the bird did not get caught, however, it quickly got discouraged when it could not get the bait.

In the second year of trapping, none of the previously caught birds would go to a bal-chatri, so we used two other methods to catch females that were no longer brooding their young but were perched nearby. We baited the female by tethering a mouse on a board (30 centimeters square) placed on the ground within 30 meters of the female. We returned for the next 2 days and repeated the procedure if the female ate the mouse. On the fourth day, we returned and set up two mist nets (2 meters high by 5 meters long, lo-centimeters mesh), parallel to each other and 2 meters apart, within sight of the female and at right angles to the perch she was on. Then we tethered a mouse on the board and placed it between the two mist nets. We watched from a distance but close enough to get to the net quickly. The net was set so that when a bird hit it, the net came off the poles and fell over the bird.

We used a second technique shortly after the young left the nest but before they could fly. We visited a nest area in the evening to locate the young. If we could not find them, we imitated their begging call and invariably they responded by begging. If we located a young bird within 12 meters of the ground, we raised toward the bird an aluminum pole (in 1.2-meter sections) with a perch on the end. Juveniles readily climbed onto the perch, and we quickly lowered them to the ground.

At this point the female usually became quite concerned and flew in for a closer look. If we kept the young on the perch above our head, the female rarely attacked us. A second person moved over to the female with a 6-meter telescoping fishing pole with a 25-centimeters noose made of 3-millimeters thick plastic cord. The noose was slipped over the owl's head and tightened around its neck; the bird was quickly lowered to the ground. The first 8 centimeters of the noose was taped to the pole to ensure that the neck would not be broken. Nooses were not used on juveniles as their neck muscles were not strong enough to withstand the stress. We noosed several males while their attention was diverted by a mouse.

For trap-shy females, we did one of two things. Once the young fledged, we studied the flight pattern of the female when she was near the young. We put up a mist net (3 by 13 meters) 9-15 meters off the ground between two trees in the path we thought the female would fly. We secured two eye screws into each of the two trees where the top and bottom ends of the net would lie. We then raised the net into place with ropes through the eye screws. The female seemed to see the net during the day, but sometimes flew into it after dark. She was quickly lowered to the ground by two ever-present observers and removed from the net. We set the net up just before dark and stayed close enough to hear the bird or see it with a light when it got caught.

We used one technique only as a last resort to remove transmitters from females after the study. We set up two parallel mist nets 2 meters apart near the fledged young and tethered a live raven between the nets. Females always attacked the raven and continued to attack it even after becoming tangled in the net. Even though this technique worked, we do not recommend it because it could condition the female not to attack ravens in close proximity to their young, which would likely mean their demise.

Males were more difficult to catch because they were more difficult to find and were more wary than females. Although males were caught by some of the techniques described above, most were caught when they came to feed the young. This method worked only if all the young had fledged and had been captured; otherwise, the male invariably fed the one young we did not get. This technique worked best if the young had been out of the nest 2-3 days; before that time, the male often took prey to the female instead of taking it directly to the young.

We set up four mist nets (2 by 5 meters) in a square near the perched young and with a 3-meter perch (tree, snag, or fabricated perch) in the middle (fig. 17). This perch provided the male with a place to land. We collected all the young and tethered two or three of them inside the nets, keeping them at least 2 meters apart to prevent squabbles. They were tethered securely to the ground with jesses on their legs. Although they liked to perch on logs they invariably fell off and became tangled. If there were more than two or three young, the others were put in separate, roomy, ventilated boxes and kept near the observers. Two observers armed with powerful flashlights sat within 15-25 meters of the nets so they could see or hear if an owl got caught. The male typically called when he arrived with prey and the young started begging. Usually the male landed on the perch inside the nets and then flew down to the young. After giving the prey to one of the young, he flew into a net as there was no other way out, and he could not gain enough height to get over the top of the net.

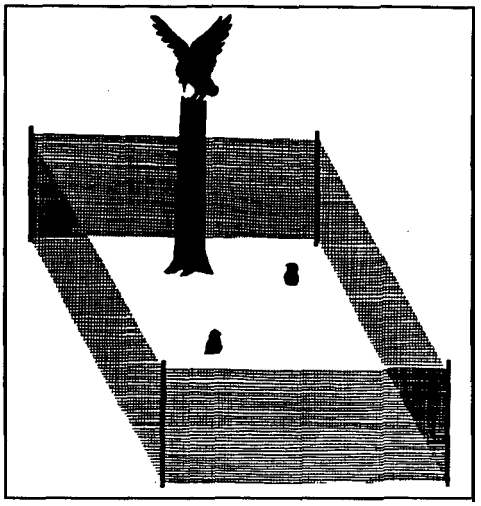


Figure 17-Technique used to trap male great gray owls shortly after the young have left the nest. Young are tethered to the ground inside a square of mist nets, and a perch is provided for the male to land on.

Once the male was caught, banded, and released, all the juveniles were fed a mouse and immediately replaced on the perch where we had found them. The mouse was to offset any delay in feeding as a result of the capture of the male; however, none of the males quit feeding the young after capture.

We set the nets up before dark and trapped at night. Most males were caught between midnight and 0400 hours, It was essential to have two people trade off the watching and listening. If the male was not caught the first night, we abandoned the attempt because of the stress put on the young birds.

Some males already radio-tagged were captured with a net gun. The net gun was powered by blank .22 shells and shot a 3-meters triangular net with three dumbbell throwers. We followed a bird around until we found him perched on a branch less than 3 meters off the ground. If the bird was higher than 3 meters, we did not shoot at it because climbers were required to get the bird and the net. We found that birds could outmaneuver a net while flying. We never used the net gun when other techniques would work, as there was considerable risk to the bird if hit with one of the throwers that carried the net.

The last trap we used was basically a metal plate with a gerbil tethered as bait (fig. 18). When the owl hits the gerbil, a hoop is released that wraps around the bird's legs. The advantages of this trap are that it is safe and easy to use and the bird gets rewarded with the gerbil even if not caught. All the birds that landed on the trap were caught, although those taking prey without landing were not always captured. A mist net on the opposite side of the trap often solved that problem.

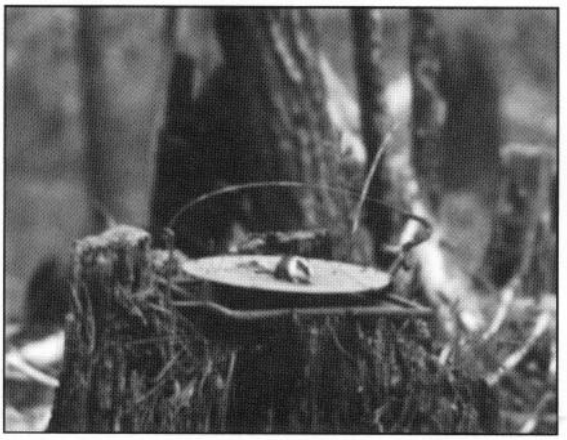


Figure 18—Trap with gerbil used to capture great gray owls.

Table 6—Weights and measurements of 30 female and 18 male great gray owls in northeastern Oregon

	Female		Male	
Measurement	Mean	Range	Mean	Range
Weight (g)	1149	1030-1310	894	763-1080
Body length (mm)	612	540-670	575	470-620
Wing length (mm)	463	430-485	433	410-455
Tail length (mm)	311	215-330	295	230-310
Bill length (mm)	40.6	38.2-46.1	40.4	32.7-43.1
Tarsus length (mm)	69.2	64.1-75.5	63.5	52.0-70.8
Tarsus width (mm)	9.8	8.9-11.9	8.9	7.6-11.8
Talon length (mm)	28.0	27.1-31.8	24.5	21.9-26.5

We always tried the safest trapping technique first, and two people were always present when trapping or handling young, because female owls frequently attacked us. Anyone climbing a nest tree or adjacent tree wore a padded jacket and a helmet with face protection because the owls often attacked the eyes. We handled the birds as quickly as possible. If we were attaching a transmitter, we wrapped each foot with a nonadhesive elastic wrap to prevent injury from the talons and covered the bird's head and body with a stretch sock with a hole cut out for the beak. The hood typically calmed the birds. We held the bird upright or placed it on its back while holding the legs. Placing the bird on its breast could cause suffocation and should never be done. As we handled the owls, we recorded weight and other body measurements listed in table 6.

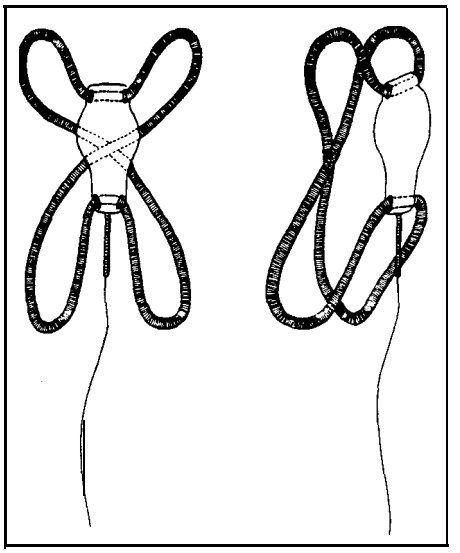


Figure 19-Backpack harness used to attach transmitter to great gray owl.

Attaching Radio Transmitters

We used a 22-gram transmitter attached with a backpack harness made from 6-millimeter tubular Teflon (fig. 19). Antennas were 30 centimeters long and made of heavy-duty material because some of the birds broke antennas of lighter material. We had several birds carry transmitters for 3 years (replaced each year) and two birds carried the same transmitter 2 years; none showed any signs of wear or abrasions.

We attached transmitters to juveniles, and because they were only 50-70 percent of their adult weight, we fitted the harnesses loosely and glued the transmitters to the feathers on the backs of the birds to hold them in place. The top loop of the harness was 21 centimeters, and the bottom loop was 31 centimeters. This harness was large enough to fit an adult female. On the juveniles retrapped as l-year-old birds, none of the harnesses were too tight.

It is essential to remove transmitters when they are no longer needed. One female we could not catch was located 2 years later with the radio dangling around her neck. We then trapped her and removed the transmitter; however, the potential existed for the loose harness to catch on a branch and strangle the bird.

Management Practices

Several things can be done to preserve, enhance, or create habitat for great gray owls. Because these owls seem to occur in local concentrations, habitat management should be done where great gray owls have been seen in the past or in prime areas. Prime areas are those with a high density of small mammals in deep-soiled open forests or deep-soiled meadows with forest edges (Forsman and Bryan 1987).

The easiest management practice is to put up nest platforms, because they are readily used and the birds often successfully raise young on them. These platforms should be open (design shown in fig. 6), placed at 9-15 meters above the ground, and located in a forested stand next to foraging areas. The platform should be positioned so that canopy cover over it provides shade and concealment from avian predators. The area immediately around and above the nest should be open so the birds can easily fly into the nest.

To provide natural nest sites, large-diameter (more than 50 centimeters d.b.h.) dead trees with broken tops should be left standing and marked so they will not be cut. Large-diameter live larch with dwarf-mistletoe provide natural stick nest platforms. Any tree with a stick platform, particularly old raptor nests, should be left standing with cover around the nest. Managing habitat for northern goshawks will provide nest sites over time for great gray owls, because the owls used old goshawk nests more than any other type of nest.

The areas used most often for nesting were unlogged, mature or older stands containing grand fir, Douglas-fir, and western larch. These stands usually contained a fairly open understory facilitating easy flight, yet a fairly dense overstory (more than 60 percent canopy closure) providing shade and concealment from above.

At all nests, dead and downed material and leaning trees are important so that the juveniles can climb them to avoid mammalian predators. In addition, a dense stand of trees around or near the nest tree provides critical cover for the juveniles for several months. It does no good to provide nest sites if the young owls are immediately killed by predators for lack of cover.

Great gray owls are efficient predators and can make an impact on a population of small mammals. A single bird can consume more than 1,400 voles in a year, and a family group can consume many more. For open areas such as clearcuts to be used by great gray owls for foraging, perches must be available for the owls to hunt from. Perches can be as short as 3 meters and should occur every 20 meters. The owls do more foraging near the edges of openings so will use a greater percentage of area in a small clearcut than in a large one.

Partial cuts are generally suitable foraging habitat because the stand is open enough for maneuvering and adequate perches are available. Dead and downed material should be left for cover for voles. Burning that destroys this downed material should be avoided.

The best way to increase populations of great gray owls is to provide the best habitat possible, meaning solid nest sites in suitable areas with adequate cover. Many juveniles are killed by avian predators; this number might be reduced by providing dense stands around nests to furnish more cover. In addition, any practice enhancing populations of voles and pocket gophers will be beneficial to these owls.

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Appendix

Scientific names of plants, birds, and mammals mentioned in this paper.

Common name	Scientific name
Plants:	
Dwarf-mistletoe	*Arceuthobium* spp.
Grand fir	**Abies** grandis (Dougl. ex D. Don) Lindl.
Western larch	*Larix occidentalis Nutt.*
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Ponderosa pine	*P. ponderosa* Dougl. ex Laws.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Birds:	
Northern goshawk	*Accipiter gentilis*
Red-tailed hawk	*Buteo jamaicensis*
Great gray owl	*Strix nebulosa*
Great horned owl	*Bubo virginianus*
Northern flicker	*Colaptes auratus*
Common raven	*Corvus corax*
American robin	*Turdus migratorius*
Mammals:	
Shrew	Sorex spp.
Vagrant shrew	*S. vagrans*
Pacific mole	*Scapanus orarius*
Columbian ground squirrel	*Citellus columbianus*
Golden-mantled squirrel	*C. lateralis*
Yellow pine chipmunk	*Eutamius amoenus*
Red squirrel	*Tamiasciurus hudsonicus*
Northern flying squirrel	*Glaucomys sabrinus*
Northern pocket gopher	*Thomomys talpoides*
Deer mouse	*Peromyscus maniculatus*
Bushytail woodrat	*Neotoma cinerea*
Heather vole	*Phenacomys intermedius*
Redback vole	*Clethrionomys gapperi*
Mountain vole	*Microtus montanus*
Longtail vole	*M. longicaudus*
Richardson vole	*M. richardsoni*
Domestic mouse	Mus *musculus*
Gerbil	*Gerbilus* sp.
Coyote	*Canis latrans*

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Information is needed on the great gray owl to understand its ecology and to consider this species in land management decisions. From 1982 to 1988, we studied 24 pairs and 107 juvenile great gray owls in northeastern Oregon. Forty-nine nests were located; 16 were used more than once, so we observed 71 nesting attempts. Seventy-eight percent of these nesting attempts were successful in raising 1 to 5 young (mean = 2.2). The nests were on stick platforms, on top of broken-off dead trees, and on artificial wooden platforms. Nest trees occurred in a variety of habitats, although most were in mature or older, unlogged stands of mixed conifer. Diet by biomass consisted mainly of northern pocket gophers (67 percent) and voles (27 percent). The size of the home range for 16 adult owls and 19 juvenile owls averaged 67 square kilometers and 157 square kilometers, respectively. Management practices enhancing habitat for great gray owls include providing artificial nest platforms, protecting existing nest platforms and large-diameter dead trees, providing dense tree cover around or adjacent to the nest, and providing perches for recently fledged young.

Keywords: Owl, great gray owl, management, conifer forest, Oregon.

Pacific Northwest Research Station
319 S.W. Pine St.
P.O. Box 3890
Portland, Oregon 97208-3890

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