Great Gray Owl (*Strix nebulosa*) Breeding Habitat Use Within Altered Forest Landscapes

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Abstract.—We investigated Great Gray Owl (Strix nebulosa) habitat use in eastern Idaho and northwestern Wyoming. Great Gray Owls were not found in severely altered habitats, but young were fledged in areas where 17 to 26 percent of formerly continuous forest had been clearcut. Average clutch (2.7) and brood (2.3) sizes were comparable to other populations, whereas juvenile mortality in the first 60 days post-fledging may have exceeded 60 percent. Habitat features were measured at independent owl activity locations, and compared pairwise with measurements at associated random points. Fledged juveniles selected micro-habitats with greater cover than was found at random locations.

Through intensive searches in 1979-1983, Franklin (1987, 1988) documented a productive population of Great Gray Owls in the eastern Idaho/northwest Wyoming portion of the Greater Yellowstone Ecosystem. Most nesting pairs were found within the lodgepole pine/Douglas fir/aspen zone, where pocket gophers (Thomomys talpoides) were the predominant prey. Groves and Zehntner (1990) did not find Great Gray Owls at historic nesting areas during 1989 surveys of the area, and suggested that Great Gray Owl numbers within the study area may have declined due to timber harvest. However, despite the Great Gray Owl's relatively large size and bold nature, Great Gray Owl habitat use remains poorly understood (Duncan and Hayward 1994). Our project was undertaken to enhance current knowledge of the conservation needs of Great Gray Owls and their habitats in southeast Idaho and northwestern Wyoming. The objectives of our ongoing study are: (1) to document productivity at selected great gray breeding areas as a baseline for long-term monitoring; (2) to learn adult and juvenile habitat use relationships within breeding areas; and (3) to determine juvenile survival parameters.

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STUDY AREA

This study was conducted from 1994-1996 in southeastern Idaho and northwestern Wyoming on the Targhee National Forest and nearby private lands. We focused on known and suspected Great Gray Owl habitat in montane forests in the foothills of the mountains that surround Teton Valley. This rural mountain basin is on the Idaho/Wyoming border approximately 24 km south of Yellowstone National Park and within the Greater Yellowstone Ecosystem. We also monitored nest sites within the southern portion of the Island Park caldera approximately 60-80 km north of Teton Valley, and in the foothills of the Big Hole Mountain Range 40 km west of the valley. Whereas most of the known Great Gray Owl nests in the study area occur within or near National Forest, wintering habitat is found on private lands in the cottonwood riparian corridors in the valley bottom (Franklin 1987).

Conifer forested foothills at 2,130 to 2,440 m elevation are found around three sides of Teton Valley. These foothills lead into three mountain ranges: the Big Holes to the west, Snake River Range to the south, and the Tetons to the east. Our study area extends west across foothill areas on the north end of the Big Holes into Madison County, Idaho. Forested stands in these foothill areas are a mixture of Douglas fir (Pseudotsuga menziesii), lodgepole pine (Pinus contorta) and aspen (Populus tremuloides), with

Englemann spruce (*Picea englmannii*), alpine fir (*Abies lasiocarpa*) forests at higher elevations.

The southern portion of the Island Park cauldera within the Ashton Ranger District features relatively flat expanses of lodgepole pine forest at elevations of 1,828 to 1,950 m. Forest stands also include pockets of Douglas fir, subalpine fir, and aspen. Most mature lodgepole stands within the study area, particularly in the Island Park cauldera, have been clearcut in the past 25 years, and most clearcuts have been planted to lodgepole. Soon after planting, most plantations are treated with strychnine to reduce populations of northern pocket gophers.

METHODS

We attempted to identify a baseline of great gray breeding area success and habitat use within the study area through careful compilation of recorded observations and survey results, and interview of private land owners. Breeding areas are defined as sites where adults laid eggs. A 1989 study (Groves and Zenhtner 1990) conducted a similar effort for the entire northeast portion of the Targhee National Forest. To examine general trends, we focused our extensive surveys on a smaller portion of the Targhee, the Teton Basin District. We hoped to thus assure more complete review of records and subsequent ground searches.

We located owls during early morning or late evening surveys, including use of taped calls when appropriate (Bull and Henjum 1990). Known historic sites and potential habitats within the study area were visited. Because great gray nest site fidelity is reportedly high (Bull and Henjum 1990), and average nesting home range was 4.5 km^2 (Bull et al. 1988, Bull and Henjum 1990) or less (e.g., Craighead and Craighead 1956), we surveyed all historic areas by walking grids within a 2 km by 2 km grid plotted around the last-known nest or location where owls were heard. Late summer we revisited areas where nests had not been located to search for fledged broods.

In 1994 we did not determine clutch size, but in 1995-1996 we recorded clutch size with a mirror pole. In all 3 years, we monitored nesting success by weekly visits to known nests. Young were banded with Fish and Wildlife Service metal bands immediately before or after fledging, and plastic-coated nylon ribbons with unique symbols were attached to the bands according to a protocol developed by Robert Nero (1980). We attempted to monitor juvenile broods from fledging until independence, when the owlets began to catch their own food. In the discussion below, the fledged, flightless period is approximately 12 days when young owls climb up trees and glide rather than fly, and independence is arbitrarily defined as 90 days post-fledging, an age when young owls are beginning to hunt for themselves (Bull and Henjum 1990). In the 1994 and 1995 breeding seasons, we tagged a total of 10 juveniles and 2 adults with 5-gm tarsal transmitters (Advanced Telemetry Systems, model 357) designed to be shed without the need for recapture. We monitored owls visually in 1996. Juveniles were captured by hand before they became capable fliers, and adults were captured with a bal chatris.

Habitat features were measured at great gray activity centers and at associated random sample points. Activity centers included nest sites, prey capture sites, and adult and juvenile perches where use was independent of observer effects. Random points were located 50 m from the activity site at a randomly selected compass bearing. By convention, the identified perches were those where birds were first located during independent, randomly selected observations. At a given site, observations were usually made twice each week. Measured habitat features at each point included perch characteristics, distance from forest edge, tree basal area as measured with a relaskop (20 factor prism, USDA Forest Service 1984), and habitat type as determined by the protocol of Steele et al. (1983). Additional features were measured as an average of measurements taken at four point centers 4.6 m from the activity point in the four cardinal directions. These features included: tree canopy area as a percentage measured with a densiometer, shrub layer, grass and forb canopy cover as percentages (Daubenmire 1959), and the total number of pocket gopher push piles seen within the plot circle (plot area = 65.7 m^2) intersected by the four point centers. We compared features at activity centers and random associated points through the two-tailed paired-sample t test (Zar 1974). We chose $P = 0.05$ as the level of significance.

RESULTS

Reproduction

We monitored productivity for 19 Great Gray broods, nine of which were first detected post-fledging (table 1). Hatch dates ranged from 28 May to 20 June. Clutch checks were completed with a mirror pole near hatching. Assuming a 36-day incubation period (Mikkola 1983), incubation was initiated between approximately 22 April and 15 May. Fledging occurred from 15 June to 15 July.

Table 1.—Known productivity at monitored Great Gray Owl (*Strix nebulosa*) nesting areas in southeastern Idaho and northwestern Wyoming, 1994-1996.

Productivity parameter	N	Average	SD	Range
Clutch size	6	2.67	0.82	2-4
Pre-fledge brood size	10	2.30	0.67	1-3
Fledged, pre-flight brood size	12	2.33	0.65	1-3
Flying brood size	19	2.16	0.50	1-3

Juvenile Survivorship Pre-Independence

We did not check clutch size until near hatching, and in most cases initiated our monitoring of juveniles at fledging. In limited monitoring of nestlings, 82.4 percent survived from hatching to fledging (n = 17). In monitoring of fledglings, 80.0 percent survived from fledging to flight (n = 30). Of the monitored juveniles that survived to flight stage (n = 24), 25.0 percent (6) were known to survive to near independence. We detected mortality of 20.9 percent (5), and lost track of 54.1 percent (13). Thus, among the monitored fledglings with known outcome (n = 17), a fledged juvenile had a 35.0 percent probability of survival to near independence. This survival estimate, a minimum, was affected by our inability to track many advanced juveniles. In 1994, transmitters unexpectedly began to fail at 40 days. Of six radio-tagged juveniles in 1994, three survived to near independence, one died, and two were lost. In 1995, all four radio-tagged juveniles were killed, the last one by humans at 72 days post-fledging. The longest we monitored any juvenile was 91 days post-fledging. Over the 3 years, 16 additional juveniles in seven broods were first located after they had attained flight. Of these, seven (44 percent) were tracked to near age of independence, with unknown outcome for the others.

In total, we noted 11 post-fledging mortalities, including, by cause: predation by Great Horned Owl (2), predation by pine marten (1), starvation (1), collision injury (2), shot by human (1), unknown causes (4).

Nest Microhabitats

Eleven different active nests were monitored within eight breeding areas, with 2 years of nesting in three of these nests. Of these, nine nests were built by goshawks (*Accipiter gentilis*) (five in Douglas fir, three in lodgepole pine, one in aspen), one by a red-tailed hawk (*Buteo jamaicensis*) (lodgepole pine snag), and one was atop a lodgepole snag. Three persisting historic nests were used in recent years; one on a Douglas-fir snag, one in a mistletoe whorl in a Douglas fir, and another in an old red-tailed hawk nest in an aspen, were not used during this study. At 10 nest sites where habitat parameters were measured, average nest tree d.b.h. was 43.6 cm (SD 18.631, Range = 23.9 - 81.8 cm), average nest height was 19.7 m (SD 6.055, Range = 7.3 - 30.2 m), average tree canopy cover was 70.6 percent (SD 25.54, Range = 29.5 - 99.0 percent), and average shrub canopy cover beneath nests was 17.2 percent (SD 19.50, Range = 0 - 54.4 percent).

Breeding Area Macro-habitats

We noted considerable habitat variation among the great gray breeding areas we monitored (table 2). We describe habitats found in three great gray breeding areas to display the range of habitats in sites where young were fledged.

At Eccles Butte, broods of three and two young fledged in 1994 and 1995 respectively. Fledglings appeared to be stressed by heat in this area, as evidenced by lethargy and panting. There was relatively little thermal cover beneath relatively thin canopied, short lodgepole pine. Great Horned Owls (*Bubo virginianus*) also used this area, and predated upon at least

Table 2.—Great Gray Owl (Strix nebulosa) breeding area macro-habitat features in eastern Idaho and northwestern Wyoming.[1]

Breeding area	Dominant tree species[2]	Percent openings	Average percent tree canopy cover	Average percent shrub canopy cover
Bustle Creek	DF	<15	60.0	24.1
Dry Hollow	DF	<15	75.6	28.4
Dry Ridge 1	LPP	20	51.4	26.6
Dry Ridge 3	LPP	20	44.7	21.6
Eccles Butte	LPP	56	37.0	0.2
Grandview	DF	<10	72.0	10.4
Hatchery Ford	LPP	56	28.1	0.1
Pole Canyon	DF	26	64.0	31.9

[1] Habitat features measured at randomly selected locations within forest stands, except for percent openings, which is a total percentage for a habitat circle of 5 km^2 around known nest sites.
[2] DF = Douglas fir (*Pseudotsuga menziesii*), LPP = lodge pole pine (*Pinus contorta*).

one juvenile great gray. From 1980-1987, 56 percent of the forest in this area was clearcut, and clearcuts were treated for pocket gophers (last treatment in 1992). Tree canopy cover at random sites averaged 37 percent, ($n = 8$, $SD = 15.900$). The forested area featured less than 1 percent shrub cover, and an average of 4.3 gopher pushpiles/plot ($n = 18$, $SD = 6.685$). Clearcuts featured very high densities of gophers. Nest sites used in this area in 1994 (top of lodgepole snag) and 1995 (red-tailed hawk nest in dead lodgepole) averaged 48.1 percent tree canopy cover ($SD = 26.929$). No owls were found here in 1996.

At Dry Ridge, two broods were fledged in 1994 (1.5 young/brood), and three in 1996 (2 young/brood). We detected no mortalities, although we suspected as many as four given the disappearance of parts of broods before independence. Great Horned Owls nested in the lower elevations of the area, and goshawks were also seen. Clearcuts and openings over the broad area where these owls were found (approximately 1,850 ha) represented 20 percent of the area. Tree canopy cover averaged 51.4 percent ($n = 27$, $SD = 14.904$). Gopher pushpiles averaged 2.1/plot ($n = 75$, $SD = 3.904$) within the forested area, with much higher densities observed in clear cuts.

In the Grandview breeding area, broods of two, three, and one fledged successfully in 1994-1996, respectively. One fledged juvenile died of starvation at 16 days post-fledging and another was eaten by a Great Horned Owl at 51 days post-fledging. A goshawk pair nested successfully near the great grays each year, and often interacted with the owls, striking the adult female during three observation periods. Great Horned Owls also nested in the area. This area features expansive Douglas fir forest with few openings at the edge of large natural meadows. Tree canopy cover averaged 72.0 percent ($n = 20$, $SD = 14.553$). Gopher pushpiles within the Douglas fir forest averaged 1.9/plot ($n = 34$, $SD = 3.440$).

Juvenile Owl Habitat Use

Juveniles generally selected perch sites in areas that featured greater tree canopy cover than was found in associated random plots. In three of four areas with adequate sample size, we rejected the null hypothesis that juveniles did not select areas with different canopy cover than available randomly (table 3). Juveniles appeared selective for multiple factors correlated with tree canopy cover, but the differences were not significant at the level selected. They appeared to select areas with greater basal area than found in random samples, and less canopy cover in understory shrubs, grasses and forbs.

Juveniles usually perched at least 15 m away from the edges of clearcuts or natural openings (table 4). We did not group these data among breeding areas because of the differences in habitat. For example, at the Grandview breeding area, which features nearly continuous, mature Douglas fir, the juveniles perched

Table 3.—Tree canopy cover (as a percentage) at juvenile Great Gray Owl (Strix nebulosa) perch sites and random sites in four breeding areas in eastern Idaho/western Wyoming, 1994-1996.

Breeding area	**Can. cover**		**Paired-sample t test statistics**				**Test result**
	Mean	**SD**	**n[1]**	**Ave. d[2]**	**SE**	**t value**	
Dry Ridge 1							
Juveniles	62.3	11.798					
			27	10.8	4.105	2.643	p = 0.015
Random	51.4	14.904					reject Ho[3]
Pole Canyon							
Juveniles	56.2	22.065					
			16	7.7	6.366	1.216	p = 0.258
Random	64.0	13.396					do not reject Ho
Grandview							
Juveniles	82.0	9.586					
			20	9.8	3.874	2.527	p = 0.021
Random	72.0	14.553					reject Ho
Bustle Creek							
Juveniles	76.7	12.905					
			22	16.7	5.073	3.285	p = 0.004
Random	60.0	22.074					reject Ho

[1] n = number of paired samples, habitat features at observed owl activity locations during independent, randomly selected observation periods compaired to associated, randomly selected sample points (see methods).
[2] The average d is the mean difference between paired measurements of percent canopy cover.
[3] Ho = canopy cover not significantly different.

Table 4.—Distance (m) of juvenile Great Gray Owl (Strix nebulosa) perches to edge of nearest opening during the pre-independence period, eastern Idaho/western Wyoming, 1994-1996.

Breeding area	**Average**	**SD**	**n[1]**
Dry Ridge 1	17.2	22.104	27
(Lodgepole pine forest, 20 percent of area in clearcuts and natural openings.)			
Pole Canyon	36.0	38.986	14
(Mixed Douglas fir/lodgepole pine forest, 26 percent of area in clearcuts and natural openings.)			
Grandview	130.4	482.505	22
(Nearly continuous mature, open-grown Douglas fir at lower edge of treeline, bordered by expansive natural meadow and brushfields.)			
Bustle Creek	17.3	14.471	19
(Nearly continuous mixed Douglas fir/lodgepole pine forest, with many small natural openings.)			
Eccles Butte	16.6	16.512	8
(Lodgepole pine forest, 56 percent of area in clearcuts)			

[1] n = number of independent juvenile owl relocations per breeding area during independent, randomly selected observation periods.

relatively far from openings throughout the monitoring period. At most areas, particularly where there were many clearcuts with large pocket gopher populations, the juveniles moved closer to openings as they matured. Advanced juveniles at near independence sometimes flew into clearcuts to intercept the adult male returning with prey.

Flighted juveniles (n = 143 independent observations) beyond 12 days after fledging perched higher in the concealment and thermal cover of the tree canopy than did younger juveniles (n = 53) ($p < 0.001$). Average perch height for the young juveniles was 5.3 m (SD = 3.002), versus an average perch height of 8.5 m (SD = 4.274) for flighted juveniles. Flighted juveniles also perched significantly higher in the canopy than adults (n = 94), whose average perch height was 5.2 m (SD = 2.982).

As juveniles neared independence, they perched at heights more similar to those of adults. Adults were often seen perched at clearcut edges, and sometimes within clearcuts on stumps or small trees. Observed adult prey capture attempts (n = 59) occurred in clearcuts or natural openings in 61 percent of observations. Pocket gophers were the prey most often (48 of 82 prey deliveries where prey species were determined) delivered to young in all but the heavily forested Bustle Creek area, where Microtus spp. were more frequently taken.

Current Breeding Activity in Historical Breeding Areas

Franklin (1987, 1988) and other observers were interviewed by Groves and Zehntner (1990) to document historical great gray nesting sites in 24 areas on the Targhee National Forest, including four areas on the Teton Basin District. None of the Teton Basin areas were known to be active after 1986. In 1989, Groves and Zehntner (1990) found no active nests, but documented observations of adults or fledged young in six locations in the Teton Basin area.

The incidental records and timber sale survey results we reviewed for Teton Basin did not represent systematic surveys and were too incomplete to yield productivity or trend data. However, they did document multiple years of Great Gray Owl occupancy of at least 16 distinct breeding areas in the breeding season, areas we labeled historic breeding areas, with historic nesting success detected in 13 areas. Multiple breeding pairs were documented in three of these areas.

We separated historic breeding areas into three categories based upon the percentage of area clearcut (table 5). Over the past 14 years, clearcutting of mature forest (lodgepole and Douglas fir) has occurred in nine of the 16 areas we examined on the Teton Basin District. No owls were detected in the four cut-over areas where an average of 49.3 percent of mature forest was cut (estimated habitat circle of 5 km^2, clearcut area range = 39 - 62 percent, SD = 11.68). In four of the five cut-over areas with more intact habitat, we saw or heard adult great grays (average area clearcut plus natural openings = 20.8 percent, range = 14 - 26 percent, SD = 5.124). We detected successful nesting in two of these areas. In one of the two areas, at least three breeding pairs successfully fledged young in 1996. Successful great gray nesting was observed in four of the seven nesting areas where only minor timber harvest has occurred.

Table 5.—Current use of historic Great Gray Owl (Strix nebulosa) breeding areas in the Teton Basin area, eastern Idaho and northwestern Wyoming, 1994-1996.

Percentage of breeding area in openings	Total number of known historical areas	Number of historical areas currently active
Clearcut area Average 49.3 percent Range = 39-62 percent	4	0
Clearcut area Average 20.8 percent Range = 14-26 percent	5	4
Minimal timber harvest Openings < 15 percent of area	7	4

We also monitored great gray broods in two areas, Hatchery Ford (two broods in 1994) and Eccles (one brood in 1994, one brood in 1995), on the Ashton District in the Island Park caldera. In these areas, 56 percent of the mature forest has been clearcut, and similar cutting intensity, followed by planting and pocket gopher control, has occurred over broad areas of the District. Although we detected no immediate effect on fledged broods during tree planting and extensive gopher control at Hatchery Ford in 1994, we did not find great grays in the area in 1995-1996. We found no owls at Eccles in 1996.

DISCUSSION

Reproduction and Juvenile Survivorship

Franklin (1987) found a mean clutch size of 3.3 eggs, a mean brood size of 3.0, mean fledgling group size of 3.0, and mean group size of 2.0 when flight was attained. These clutch and brood sizes were statistically similar to those found for other studies in North America (Duncan and Hayward 1994), but smaller than reported for Scandinavia. Our clutch (2.7) and nestling (2.3) brood sizes were smaller than Franklin (1987) found in this area, but within the range expected in North America.

Franklin (1988) reported that a young great gray had a survival probability of 0.76 through incubation as an egg (n = 25), 0.89 survival probability from hatching to fledging (n = 19), and 0.77 survival probability from fledging to flight stage at approximately 14 days post-fledging (n = 13). Bull et al. (1989) noted that nine of 33 radio-tagged juveniles in Oregon died before independence. Bull et al. (1989) also reported that juveniles had a 0.53 probability of surviving their first 12 months. High mortality of juveniles once they leave their natal area, at independence, may be attributable to inexperience (Duncan 1987). Starving young owls may be less wary of predators and more intent on foraging, and unfamiliarity with a new habitat puts them at a disadvantage when faced with that habitat's predators.

Our small sample sizes and lack of a population estimator prevent a clear estimate of juvenile mortality. However, the high mortality we observed before independence is cause for concern given that additional mortality might be expected when juveniles become independent of adults. Some of the more severely altered habitats may have become ecological traps for breeding Great Gray Owls; these areas have abundant prey but insufficient cover to ensure that adequate numbers of juveniles survive. Juvenile mortality is of far less concern than adult mortality for relatively long-lived species such as Great Gray Owls, but could limit population sustainability if too extreme. Further study is needed to determine conclusively if habitat alterations have resulted in increased juvenile mortality.

Habitat Use

Of 15 nests that Franklin (1987, 1988) monitored in our region, 60 percent were in broken-topped snags and 40 percent on stick nest platforms, primarily nests built by accipiters. In our study, we found a shift to more stick nests (91 percent of active nests). Fewer older growth snags are currently available, in part because of stem age and firewood cutting.

Our habitat selection study suggests that juvenile great grays require security cover. We measured habitat features at random points close enough to activity points to be within similar habitat. This allowed us to detect selectivity for denser canopy cover than found at random sites. Bull and Henjum (1990) reported that owlets remained in forests with at least 60 percent canopy closure.

There were not statistically detectable differences between activity locations and random points for more general features such as slope or slope aspect; our random points were near enough to the activity points as to usually be within the same slope. However, monitored great grays avoided steep slopes, particularly northern exposures which are heavily covered with shrub understory in our locale. They also avoided dense, young stands of lodgepole pine in plantations.

Basal area did not prove to be an indicator of habitat selectivity, but in review, this measurement has little meaning unless coupled with stem density and size. We are attempting to develop a better index of features that may be important to Great Gray Owls.

Over the broader landscape, Great Gray Owls in our study area may have demonstrated considerable adaptability to habitat alteration. However, removal of over 50 percent of forest cover may eliminate great gray production in traditional nesting areas. One important factor may be that primary stick nest builders, e.g., goshawks, may have lesser tolerance to habitat alteration than the owls, and thus not provide nest structures. We also suspect that juvenile great gray mortality may be greater in these habitats. Our ongoing investigation of the landscape ecology of Great Gray Owls in eastern Idaho, northwestern Wyoming is in a preliminary stage.

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