BREEDING SEASON HABITAT USE AND ECOLOGY OF MALE NORTHERN PYGMY-OWLS

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ABSTRACT.—We examined habitat use, nest location, diet, and activity patterns of radio-marked Northern Pygmy-Owls (*Glaucidium gnoma*) during four breeding seasons (1994–97) in fragmented forests on the Olympic Peninsula, Washington. We observed foraging in all available vegetation categories, but patterns of use were non-random. Structurally diverse and older forests were most heavily used, openings and patches of saplings received the least use, and use of edge was intermediate. We located eight nests, all in woodpecker cavities in patches of structurally-diverse forest. We found no clear evidence that nests were located near edges. Northern Pygmy-Owls were diurnally active, and male owls delivered food to females during nest establishment and incubation, and to both females and nestlings during brooding. Date of fledging varied from mid-June to mid-July. Fledging was synchronous, and minimum estimates of brood size ranged from 1–5. Diet included a mix of small birds, mammals and insects. Our results suggest that the creation of openings by clear-cut logging is unlikely to benefit Northern Pygmy-Owls, and that the replacement of structurally diverse forests with uniform forests may be detrimental.

KEY WORDS: *Northern Pygmy-Owl; Glaucidium gnoma; fragmentation; habitat use.*

ESTACION REPRODUCTIVA, USO DE HABITAT Y ECOLOGIA DEL BUHO PIGMEO MACHO DEL NORTE

RESUMEN.—Examinamos el uso de hábitat, la localización de nidos, la dieta y los patrones de la actividad de búhos pigmeos (*Glaucidium gnoma*), durante cuatro estaciones reproductoras (1994–97) en bosques fragmentados en la península Olympic, en Washington. Observamos el forrajeo en todas las categorías de vegetación disponibles, cuyos patrones de uso no estaban determinados por el azar. Los bosques más viejos y estructuralmente diversos fueron los más usados, los claros y parches de árboles fueron los mucho menos usados, la utilización de bordes fue intermedio. Localizamos ocho nidos, todos en cavidades de carpinteros en parches de bosques estructuralmente diversos. No encontramos ninguna evidencia clara que los nidos estuvieran situados cerca de los bordes. Los búhos pigmeos del norte fueron más activos durante el día, los búhos machos entregaron el alimento a las hembras durante el establecimiento de nidos y la incubación, tanto a hembras y pichones durante el empollamiento. La fecha de crecimiento de plumas en que los polluelos debían abandonar el nido varió a partir de mediados de junio hasta mediados de julio. El crecimiento de plumas fue sincrónico y las estimaciones mínimas del tamaño de la nidada fluctuaron entre 1 y 5. La dieta incluyó una mezcla de pájaros, mamíferos e insectos pequeños. Nuestros resultados sugieren que es poco probable que la creación de claros por la tala beneficie al búho pigmeo del norte y que el reemplazo de bosques estructuralmente diversos por bosques uniformes puede ser perjudicial.

[Traducción de César Márquez]

Holt et al. (1990) labeled the Northern Pygmy-Owl (*Glaucidium gnoma*) North America's least-studied owl. Thirteen years later, detailed information for this locally-common inhabitant of western forests remains scant, and published information is often equivocal. Yet western forests have experienced decades of intense resource extraction pressure (Parry et al. 1983) and it is presently impossible to estimate how such changes might affect Northern Pygmy-Owls. Here, we report on Northern Pygmy-Owl habitat use and ecology in forests heavily fragmented by clear-cut logging.

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The range of the Northern Pygmy-Owl extends from Alaska to Central America, including forests from the west coast to the Rocky Mountains (Johnsgard 1988). They are diurnally active, use cavity nests, and are generalist predators of small birds, mammals, and insects (Bent 1938, Johnsgard 1988). Northern Pygmy-Owls have been commonly sighted in or near openings, leading to statements that they preferentially foraged in openings (Bent 1938, AOU 1983, Johnsgard 1988), nested near edges (Webb 1982, Reynolds et al. 1989), and might benefit from partial forest clearing (Johnsgard 1988). In contrast, others have suggested that partial forest clearing may be detrimental to Northern Pygmy-Owls (Marshall 1992).

Hayward and Garton (1988) used call-response surveys to examine resource partitioning by small forest owls in Idaho and concluded that the Northern Pygmy-Owl was a habitat generalist. Although their work is the most extensive study to date, many questions remain about habitat use by this species. We used radiotelemetry to study habitat use for two behaviors, foraging and nesting. We were specifically interested in whether partial forest clearing might benefit this species. We also describe home range size, diet, activity patterns, nest characteristics, and nesting behavior. For the purposes of this paper, we hereafter use 'Northern Pygmy-Owl' and 'owl' synonymously.

METHODS

The study area was a mixture of federal, state, and private lands on the northwest corner of the Olympic Peninsula, Washington. The area was hilly to mountainous with elevations ranging from 50–1350 m. Mean annual precipitation ranged from 150–250 cm. Natural vegetation was dominated by coniferous forests of western hemlock (*Tsuga heterophylla*), Douglas-fir (*Pseudotsuga menziesu*), western red-cedar (*Thuja plicata*), and silver fir (*Abies amabilis*). Valley bottoms typically included variable amounts of bigleaf maple (*Acer macrophyllum*) and red alder (*Alnus rubra*) (Henderson et al. 1989). Even-aged patches of primarily Douglas-fir resulted from logging and silviculture.

We located owls by walking logging roads while vocally imitating their calls. Surveys were conducted during April and May 1994–97, and were not designed to sample the study area equitably. Rather, we concentrated on areas where we had observed owls previously, and surveyed other areas less intensively. When found, owls were captured in mist nets, marked with bands issued by U.S. Geological Survey Bird Banding Laboratory; and fitted with backpack transmitters (Model BD-2G ca. 2.5 g with harness, Holohil Systems Ltd., Carp, Ontario, Canada).

Radio-marked owls were relocated several times each week during the 15-wk transmitter life span. We worked from a sequential list of radio-marked owls, locating as many owls each day as possible (typically two to eight) and beginning where we had finished the day before Thus, each owl was located at all times of the day, because a new owl typically topped the list each day. Location times ranged from about an hour before sunrise to about an hour after sunset.

We classified habitat into five vegetation categories based on structural characteristics. The *Open-Sapling* category included areas dominated by small conifer saplings (1–4 m tall) intermixed with extensive areas (>25% cover) of bare ground and shrub cover, mostly on recent clear-cuts. The *Early Stem Exclusion* category was dominated by young conifers (5–15 m tall) with few openings in the overstory and with dense, overlapping limbs in the understory. The *Late Stem Exclusion* category was dominated by medium-sized conifers (typically 20–40 cm DBH and >15 m tall) with a closed canopy and open understory. The *Structurally Diverse* category was characterized by a wide variety of tree sizes and a multilayered canopy. It consisted primarily of mature and older forests (typically >80 yr), but also included mid-aged stands characterized by high structural diversity. Finally, the *Edge* category included all areas within 30 m of an intersection between a patch of *Open-Sapling*, and any of the other categories. Thirty meters was used because pilot-study observations suggested that foraging flights by Northern Pygmy-Owls rarely exceeded this distance. A foraging flight was defined as any flight which included or ended with an attempt to capture prey. Because patchiness in the study area was predominantly the result of clear-cut logging, patches were generally easy to delineate and classify. We delineated patch boundaries using ARC/INFO (ESRI, Redlands, CA) and digital orthophotographs. We visited each patch and based vegetation classifications for both used and available cover on visual inspection.

We used compositional analysis (Aebischer et al. 1993) and program RESELECT (Leban 1994; available at http.//ces.iisc.ernet.in/hpg/envis/resdoc1120.html) to compare relative use among vegetation categories. Compositional analysis treats the individual as the sampling unit, accounts for the unit-sum constraint of proportions, and allows unique availability for each individual. We used an F-test to determine study-wide deviation from random usage, and pairwise t-tests for differential use between vegetation categories.

Use ratios were calculated by dividing proportionate use by proportionate availability. Proportionate use was defined as the proportion of locations for a given owl in a given vegetation category. All locations were determined by homing to an owl with a hand-held receiver until the owl was located visually, or until triangulation indicated that the owl was directly overhead. Locations were mapped in the field on aerial photographs and subsequently digitized using digital orthophotographs. Locations of owls <50 m from an active nest were not included in the analyses because of the possibility that those locations represented nest activity rather than foraging. Removal of such locations would introduce bias if they were foraging locations. However, because all nests were located in the most heavily-used vegetation category (see below), this bias would be conservative relative to our conclusions. We assessed the error associated with

overhead triangulations by mapping the location of 12 transmitters placed in trees by an independent observer.

Proportionate availability was defined as the proportion of a given vegetation category within the minimum convex polygon (MCP) that encompassed the locations for a given owl. We used the MCP for availability because we believe it best approximated the area in which a breeding owl had the opportunity to forage. A circle centered on the nest was unsatisfactory because our pilot study revealed that nests were not always centrally located within territories, and territorial overlap was minimal. Thus, vegetation within such a circle might receive little use due to the presence of a neighboring owl. Alternatively, kernel estimators (Seaman et al. 1998) are more biased toward heavily-used vegetation patches than are MCPs, and may exclude areas that are available but used infrequently. We evaluated the sufficiency of our availability estimates with a *post hoc* analysis of MCP size in relation to the number of relocations. An inflection point was apparent at ca. 30 locations so we removed owls from further analysis if they either died or left the study area before we had accumulated 30 locations.

For comparison, we estimated home range sizes using both 100% MCP and 95% fixed kernel methods. In general, owls in this study occupied well-defined home ranges during the breeding season. However, one owl made two excursions of 6 and 11 km from its core use area for three days each in April, and then returned and nested near its original trapping location. We removed the six locations collected during these excursions from MCP home range estimation, but included them in the kernel estimates. Reynolds and Linkart (1990) discussed extra-range movements in Flammulated Owls (*Otus flammeolus*) and Linkart et al. (1998) removed extra-range movements from their home-range determinations. Programs CALHOME (Kie et al. 1996) and KERNELHR 4.28 (Seaman et al. 1998) were used for MCP and kernel analyses, respectively.

Nests were located by observing males delivering food to incubating females. The distance from each nest to the nearest edge (d_n) was measured in the field with a 50-m tape and compared to the mean distance-to-nearest-edge (d_r) for 100 randomly generated points in the same stand. Random points and associated distances were generated with ARC/INFO. A studentized Z-statistic was calculated for each nest (Eq. 1)

$$Z = (d_n - \bar{d}_r)/s_r \qquad (1)$$

where s_r is the standard deviation of the random point distances. We used a one-tailed *t*-test to test for $Z < 0$. We climbed to each nest post-fledging and measured cavity entrance and tree dimensions. Tree heights >20 m were estimated with a clinometer. We collected pellets and prey remnants from the ground near nests two to three times per wk, and recorded all observations of owls with prey. We pooled pellets and remnants for each collection date and nest, and estimated minimum vertebrate prey counts for each pooled sample. Each pellet was treated as independent for counts of insect prey. We recorded owl behaviors during three dawn-to-dusk nest watches and 34, 2-hr focal animal observations.

RESULTS

We radio-marked 21 owls during four field seasons (1994–97), including 16 males, one female, and four sex-unknowns. We had sufficient data to estimate ranges and conduct habitat use analyses for nine males (Table 1). Of those, six nested and fledged young, one nested and failed to fledge young, one nested and was thought to have failed, and the nesting status of one was undetermined. Radio-marked owls excluded from the analysis of habitat use included four males with fewer than 30 locations (Table 1), four that left the study area, two that died, one whose sex was unknown, and one female. Although we surveyed in consecutive years, we never trapped any previously banded owls.

We collected a mean of 49 locations per owl (range = 34–66, $N = 9$). Estimates of home range size (mean ±SE) were 296 ± 42 ha ($N = 9$) for the MCP method and 209 ± 28 ha ($N = 9$) for the fixed kernel method (Table 1). Of all locations, 49% were confirmed visually and 51% were estimated by triangulation. Estimated triangulation error (mean ±SE) for transmitters placed in trees was 11.6 ± 2.3 m ($N = 12$).

Use of vegetation categories for foraging was nonrandom ($F_{4,5} = 29.41$, $P < 0.01$). The *Structurally Diverse* category was the most used, followed by *Late Stem Exclusion*, *Edge*, *Early Stem Exclusion*, and *Open-Sapling* (Table 2). Confidence in the rank assignments for the *Open-Sapling* and *Structurally Diverse* categories was high, as indicated by low *P*-values for pairwise comparisons of rank with other vegetation categories. Confidence in the relative ranks of *Late Stem Exclusion*, *Edge*, and *Early Stem Exclusion* was low, as indicated by mostly non-significant *P*-values for pairwise comparisons. Our results suggested a dichotomy between 'forested' and 'non-forested' vegetation categories. We reanalyzed the data with the *Open-Sapling* category removed and found that the relationships between the remaining categories were qualitatively unchanged. We also analyzed the data with and without the one owl whose nesting status was not confirmed and the results were again qualitatively unchanged.

We located eight nests, all of which were in dead trees in cavities excavated by woodpeckers (Table 1). Estimated distance to the nearest edge ($\bar{x} \pm$ SE) was 59 ± 16 m for the nests and 99 ± 3 m for the random points. The studentized difference be-

Table 1. Nest characteristics and home range sizes for adult male Northern Pygmy-Owls on the Olympic Peninsula, WA, 1994–1997.

| | Cavity Entrance | | Nest Tree | | | Fledglings | | Home Range Size (ha) | | | |
Site-Yr	Height (m)	Diameter (mm)	Species[a]	DBH[b] (cm)	Height (m)	Minimum No.	Fledge Date	MCP[c]	N	Fixed Kernel	N
LB-94	5	55	TSHE	62	8	Unknown		—	—	—	7
UB-94	16	50	TSHE	96	23	2	25 June–8 July	—	—	—	51
LB-95	6	52	TSHE	31	10	3	22 June	—	—	—	11
LC-95	5	46	TSHE	46	10	3	3 July	—	—	—	15
WC-96	6	56	TSHE	40	11	5	20 June	235	43	342	43
SK-96	Not located		—	—	—	4	14–18 June	169	40	190	40
LB-96	Not located		—	—	—	1	26–28 June	207	51	145	51
BC-96	Not located		—	—	—	Unknown		318	39	277	39
UB-97	3	57	TSHE	84	8	3	13–15 July	202	34	176	34
BC-97	8	57	ALRU	32	10	3	17 July	561	46	83	52
LB-97	Not located		—	—	—	Suspected nest failure		245	60	216	60
WC-97	Not located		—	—	—	1	10–16 July	298	64	308	64
SD-97	18	58	TSHE	54	26	Failed (eggs broken)		428	66	142	66
Mean	8.4	53.9		55.7	13.3	2.8		296	49	209	50

[a] TSHE = *Tsuga heterophylla* and ALRU = *Alnus rubra*.
[b] DBH = diameter at breast height.
[c] MCP = minimum convex polygon.

Table 2. Use of vegetation categories by adult male Northern Pygmy-Owls on the Olympic Peninsula, Washington, 1996–97, expressed as logged use-ratio differences (SE). A positive value indicates that relative use for the row category exceeded that of column category. Categories are ranked from most (4) to least (0) used by adding the number of positive use-ratio differences across rows.

VEGETATION CATEGORY	OPEN-SAPLING	EARLY STEM EXCLUSION	EDGE	LATE STEM EXCLUSION	STRUCTURALLY DIVERSE	RANK
Open-Sapling		−2.02** (0.51)	−2.68** (0.40)	−2.74** (0.47)	−3.44** (0.33)	0
Early Stem Exclusion	2.02** (0.51)		−0.66 (0.48)	−0.72 (0.51)	−1.42* (0.49)	1
Edge	2.68** (0.40)	0.66 (0.48)		−0.06 (0.35)	−0.76** (0.17)	2
Late Stem Exclusion	2.74** (0.47)	0.72 (0.51)	0.06 (0.35)		−0.70 (0.31)	3
Structurally Diverse	3.44** (0.33)	1.42* (0.49)	0.76** (0.17)	0.70 (0.31)		4

* $P < 0.05$ from two-tailed t-tests for pairwise differences in log-ratios.
** $P \leq 0.005$ from two-tailed t-tests for pairwise differences in log-ratios.

tween nests and random points ($\bar{x} \pm$ SE) was $Z = -0.51 \pm 0.31$, and did not provide sufficient evidence to show that nests were associated with edges (One-tailed $t_7 = 1.64$, $P = 0.07$). All nests were located in *Structurally Diverse* forest patches, and seven nests were in patches of late successional, (>200 yr old) coniferous forest. The eighth nest was in a relatively young, mixed patch of coniferous and deciduous trees that had regenerated naturally following logging.

Northern Pygmy-Owls consumed a variety of small birds, mammals and insects (Tables 3 and 4), and males provisioned females and nestlings during incubation and brooding. In ca. 100 hr of nest observation we saw no indication of females foraging. We observed females accepting prey items from males and retrieving cached prey items, but not leaving or returning with fresh prey items of their own. During dawn-to-dusk observations at three nests, females were either in the nest cavity or perched within 50 m, and radiotelemetry suggested that males visited the nest stand every 1–3 hr. Additionally, during the egg-laying period, fe-

males typically perched near the nest while males foraged and delivered food. We documented date of fledging for nine nests (Table 1). At four nests we observed chicks exiting the nest, and in each case, all known chicks from a given nest exited within a 6 hr period. Minimum estimates of brood size varied from one to five based on the maximum number of fledglings observed simultaneously (Table 1).

DISCUSSION

We found strong evidence that patterns of use differed from patterns of availability, indicating that owls discriminated between the vegetation categories we defined. Although use was concentrated in structurally-complex forests, we observed foraging flights in all vegetation categories. Therefore, locations in seldom-used categories cannot be attributed to owls in transit. Use of edges (as defined here) was proportionate to availability, the least used vegetation category consisted primarily of recent clear-cuts, and nests did not appear to be associated with edges. Thus, our results suggest that

Table 3. Percent composition of the diet of adult male Northern Pygmy-Owls on the Olympic Peninsula, Washington, 1996–97, based on three different methods of data collection.

METHOD	N	MAMMALS	BIRDS	INSECTS	TOTAL
Direct observation	59	45.8	50.8	3.4	100.0
Pellet analysis	83	59.0	18.1	22.9	100.0
Prey remnants	8	12.5	87.5	0.0	100.0

Table 4. Species of mammals and birds identified as prey of adult male Northern Pygmy-Owls on the Olympic Peninsula, Washington, 1996–97, based on direct observation, pellet analysis and prey remnants.

MAMMALS	BIRDS
Shrew (*Sorex* sp.)	Gray Jay (*Perisoreus canadensis*)
Coast mole (*Scapanus orarius*)	Chestnut-backed Chickadee (*Poecile rufescens*)
Deer mouse (*Peromyscus maniculatus*)	Brown Creeper (*Certhia americana*)
Red-backed vole (*Clethrionomys gapperi*)	Winter Wren (*Troglodytes troglodytes*)
Vole (*Microtus* sp.)	Golden-crowned Kinglet (*Regulus satrapa*)
Townsend's chipmunk (*Tamias townsendii*)	Thrush (*Catharus* sp.)
	Varied Thrush (*Ixoreus naevius*)
	Dark-eyed Junco (*Junco hyemalis*)
	White-crowned Sparrow (*Zonotrichia leucophrys*)
	Golden-crowned Sparrow (*Zonotrichia atricapilla*)

the creation of openings by clear-cut logging is unlikely to benefit Northern Pygmy-Owls and that the replacement of structurally diverse forests with uniform forests may be detrimental. This conclusion is subject to the caveat that habitat use may vary temporally, and we cannot exclude the possibility that different types of habitat receive heavier use in different seasons or years.

Owls in this study did not use edge habitat or openings heavily, and detection bias is one plausible explanation for this inconsistency with previous anecdotal accounts. Prior to initiating this radio-telemetry study, we observed Northern Pygmy-Owls most frequently in recent clear-cuts and along edges. Moreover, our visual confirmation rate was approximately 50% for owls in forests, compared to 100% for owls in openings. Alternatively, edges and openings created by clear-cut logging may differ in important ways from edges and openings in other contexts. For example, transitional vegetation was all but absent in our study area. Also, our definition of a 30-m buffer to define edges was arbitrary, and other definitions of edge might lead to different conclusions. Lastly, we assumed that the owls we tracked were foraging. While we attempted to strengthen this assumption by focusing on nesting males and eliminating locations near nests, we cannot demonstrate that our data reflect use for foraging. If owls used different vegetation categories for different activities, important use of some categories might be obscured by our analyses. These alternative explanations should be tested before general conclusions regarding edge associations of Northern Pygmy-Owls are drawn.

We also failed to find support for the idea that Northern Pygmy-Owls use nests near edges. How-

ever, our sample was small and the results were nearly significant ($N = 8$, $P = 0.07$). Furthermore, our approach assumed that potential nests were evenly distributed in forest patches. While it would be useful to know the true distribution of potential nests, estimating such a distribution would be problematic, and might only be relevant if potential nests were in limited supply. Our analyses were also sensitive to scale. The mean distance from a nest to the nearest edge (59 m) may be a biologically meaningful proximity that was not statistically significant in our study due to an abundance of edges. A mean distance of 99 m from random points to the nearest edge gives an indication of the ubiquitousness of edges in our study area.

Based on an analysis of forest characteristics at locations where owls responded to a vocal lure, Hayward and Garton (1988) concluded that the Northern Pygmy-Owl was a habitat generalist. At least two plausible and non-mutually exclusive hypotheses can explain the differences between their conclusions and ours. First, owls might behave differently on different study areas and second, owls might use different criteria to select habitat for home-range location, calling, and foraging. The owls we studied occupied home ranges that encompassed a diverse array of vegetation categories, but they predominantly used a subset of those categories. Additionally, calling locations and foraging locations appeared to differ (see below). Two important differences between our study and that of Hayward and Garton are that they apparently surveyed for owls at night, whereas our locations were crepuscular and diurnal, and their study included many vegetation types across a broad range of elevations.

Our results suggest the need for care when evaluating habitat associations of Northern Pygmy-Owls from opportunistic sightings or vocal lure surveys. First, of 21 owls radio-marked, 11 were initially detected responding to playbacks from forest edges (unpubl. data), yet our analyses on a subset of nine of these owls did not indicate disproportionately heavy use of edge habitat. This can most easily be explained if owls reacted to calling surveys by moving toward the perceived source before vocalizing. Proudfoot et al. (2002) documented the movement of Ferruginous Pygmy-Owls (*Glaucidium brasilianum*) toward calling stations. In our case, because surveys were conducted from logging roads, this would tend to pull owls toward edges of clear-cuts. However, we cannot exclude the possibility that edges are selected as sentinel perch areas for calling. Second, of the same 21 radio-marked owls, only 12 established territories inclusive of their original response location (unpubl. data). Lastly, we occasionally detected responses from multiple owls on the same territory at different times during a season, again suggesting that calling location and territory location may be decoupled. From our experience, the surest way to document Northern Pygmy-Owls in residence would be to repeatedly detect unsolicited vocalizations from the same area.

None of the owls that we radio-marked were relocated in subsequent years. We did monitor nesting owls in consecutive years at the same site in five cases (LB-94/95, 95/96, 96/97, WC-96/97, and BC-96/97; Table 1). Additionally, there were three sites used in one season, but vacant in the following season (UB-94, LC-95, and SK-96), for a total of eight sites where a resident male was not found at the same site in the following season. Possible explanations include: (1) nest-site fidelity was low, (2) mortality was high, (3) the study area was a population sink, and (4) radio-marking negatively affected the owls we worked with by either increasing their mortality or inducing them to find new territories. Information on the annual movements of Northern Pygmy-Owls would be useful in evaluating these hypotheses.

Seven of the eight nests we located were in late successional forests. This finding, coupled with high use in the same types of forest suggests that the loss of late-successional forest may negatively affect Northern Pygmy-Owls. However, one nest was in a mid-aged stand that differed from most of the mid-aged stands in our study area by having greater structural diversity. This suggests that logging practices that do not result in monocultural plantations may have a lesser impact.

Our findings are similar to those of a recent study of habitat use by the Eurasian Pygmy-Owl (*Glaucidium passerinum*) (Strom and Sonerud 2001). Home range sizes for males in their study (100% MCP, 40–600 ha) overlapped our estimates and habitat use patterns were similar, except that they found that *Edge* was the highest ranked category for the Eurasian Pygmy-Owl. However, they defined *Edge* to be a 10-m-wide strip, where forest vegetation bordered open areas. To facilitate comparisons, we reanalyzed our data using their definition of *Edge*. It is important to note that although *Edge* had the highest relative rank in their study, it did not differ significantly from either of the next two highest ranked cover types (analogous to our *Structurally Diverse* and *Late Stem Exclusion* vegetation categories). In our reanalysis, the *Structurally Diverse* category again had the highest relative rank, followed by *Edge*, *Late Stem Exclusion*, *Early Stem Exclusion*, and *Open-Sapling* (results not shown). However, the relative rank of *Edge* was not significantly different than any category type except *Open-Sapling*. Thus, even though the relative rank for *Edge* increased by one, there was still insufficient evidence to conclude that Northern Pygmy-Owls used edges disproportionately.

Our natural history observations support much of the consensus knowledge regarding Northern Pygmy-Owls. We observed synchronous fledging in four instances and the dates of fledging were more similar within years than between (Table 1). The owls that we observed also exhibited a diverse diet, consistent with previous reports (Earhart and Johnson 1970, Snyder and Wiley 1976, Holt and Leroux 1996). However, we have no information on relative prey availability, and owls may exhibit prey preferences that would not be apparent in simple tallies.

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