Forest Age and Relative Abundance of Pileated Woodpeckers on Southeastern Vancouver Island[1]

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Abstract

We estimated relative abundance of the pileated woodpeckers *(Dryocopus pileatus)* at four sites in the Coastal Western Hemlock Biogeoclimatic zone, on southeastern Vancouver Island during 1996-1997. The number of pileated woodpecker calls was correlated with age and structure of forests. Pileated woodpeckers did not use intensively managed forests < 80 years old that had low densities of dead wood (large snags and logs). They were most abundant in forests that had greater densities of dead wood and where 51 percent of the area was covered by >140-year-old stands. However, their abundance in these forests did not differ significantly from that in early seral forests (49 percent > 80-year-old stands) or old forests (70 percent > 140-year-old stands).

Introduction

The pileated woodpecker *(Dryocopus pileatus)* is an important species in forests of North America because, as a primary cavity nester, it creates habitat opportunities for secondary cavity nesters. It is the largest extant woodpecker species in North America and, because of its size, excavates large cavities. Hence, many species benefit from its nesting and roosting activities (Bunnell and others 2002). Loss of structural elements (e.g., logs, snags, and trees with broken tops, scars, decay, or damage) has the most significant impact on pileated woodpecker habitat; forest fragmentation likely reduces population density and makes pileated woodpeckers vulnerable to predation as they fly between forest fragments (Bull and Jackson 1995).

We estimated relative abundance of pileated woodpeckers in relation to habitat types and stand characteristics in the Coastal Western Hemlock Biogeoclimatic zone on southeastern Vancouver Island. For our study, we define relative abundance as the number of responses (the number of pileated woodpeckers calling or drumming in response to a recording) received per call station within an area. Relative abundance can be used to infer the quality of the habitat for species, and differences in the

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abundance of bird species often reflect the availability of resources to them (Schoener 1968).

Our objectives were to estimate relative abundance of pileated woodpeckers in different seral stages and structure classes of forest stands and examine associations between habitat features and abundance of pileated woodpeckers. We hypothesized that the relative abundance of pileated woodpeckers increases as age of forest increases and as the amount of forest harvesting decreases. We also expected that landscapes with greater quantities of dead or decayed large forest structures (i.e., snags, defective trees, and logs) will have a greater abundance of pileated woodpeckers.

Methods

Study Area

We selected our study area on southeastern Vancouver Island because it has a population of pileated woodpeckers (determined from historical records [Campell and others 1990] and from pilot surveys), a range of forest conditions, and because commercial timber harvesting occurs in the region. Forest management for timber in each site ranged from 100 percent logged and 60-80 percent spaced in the early seral study site, 40 percent logged and 39 percent spaced in the mid-seral study site, 20 percent logged and 4 percent spaced in the mature study site, and 22 percent logged and 5 percent spaced in the mature/old study site. The study area is located within the Very Dry Maritime Coastal Western Hemlock Biogeoclimatic subzone (CWHxm) (Anonymous 1993). It has warm, dry summers and moist, mild winters (Green and Klinka 1994). Forests in the CWHxm subzone are coniferous, dominated by Douglas-fir *(Pseudotsuga menziesii),* western hemlock *(Tsuga heterophylla),* and minor amounts of western red-cedar *(Thuja plicata),* but some deciduous species such as red alder *(Alnus rubra)* and bigleaf maple *(Acer macrophyllum)* occur (Green and Klinka 1994).

Field Methods

We established four 1,450-ha study sites. Each study site encompassed an area equal to the home ranges of approximately two to three breeding pairs of pileated woodpeckers. Home range size was estimated to be 478 ha for individuals after young fledged in coastal western hemlock climax forests dominated by Douglas-fir (Mellen and others 1992). The four sites represented four landscapes that differed in seral stage and forest structure. The Hillridge site was a homogeneous, early seral forest with few snags and medium numbers of large logs remaining after cutting of the primary forest *(tables 1, 2).* Niagara was a mid-seral forest with abundant remnant large snags and logs. Sooke was a mixed forest with early and mid-seral forests and mature/old forests with abundant remnant large snags and logs. Rithet represented most closely an unlogged mature/old seral forest with abundant snags and a modest number of logs.

Table 1—*Percentage of forest stand age classes in four pileated woodpecker study sites on southeastern Vancouver Island.*

Study site	Early seral ≤ 60 years	Mid-seral 61-100	Mature 101-140	Mature/old >140	Non-forest
Hillridge	73	27	0	0	0
Niagara	47	22	14	13	5
Sooke	26	9	0	51	13
Rithet	22	5	3	70	1

Table 2—*Mean (± SE) or percent frequency of forest characteristics of four pileated woodpecker study sites on southeastern Vancouver Island, 1996-1997.*

	Study sites (n = plots)				
Characteristic	**Hillridge (10)**	**Niagara (19)**	**Sooke (20)**	**Rithet (10)**	***P***
Coarse woody debris (m^3 ha^{-1})	75 (± 19)	176 (± 33)	213 (± 39)	114 (± 34)	[1]0.11
Snag or defective tree basal area (m^2ha^{-1})	0.7 (± 0.2)	4.3 (± 1.3)	7.1 (± 1.4)	11.9(± 2.5)	[1]<0.01
Stem density (stems ha^{-1})	1,810 (± 818)	688 (± 154)	355 (± 110)	760 (± 130)	[1]<0.01
Structural stage (pct)					[2]<0.01
Shrub	0	26	0	0	
Pole/sapling	30	37	5	0	
Young forest	70	21	30	10	
Mature forest	0	16	40	60	
Old forest	0	0	25	30	
Successional stage (pct)					[2]<0.01
Pioneer or young seral	70	58	5	0	
Mature or overmature seral	10	21	15	10	
Young climatic climax	20	10.5	20	10	
Maturing climax, maturing climatic climax and disclimax	0	10.5	60	80	
Disturbance (pct)					[2]<0.01
Logging, thinning, or spacing	100	84	40	0	
Fire, wind, or edge	0	16	25	70	
None	0	0	35	30	
Elevation (m)	387 (± 21)	518 (± 13)	371 (± 33)	537 (± 42)	[1]<0.01

[1]Kruskal-Wallis comparison among four study sites.
[2]Chi-square test between two young study sites (Hillridge and Niagara pooled) and two older study sites (Sooke and Rithet pooled).

Transects and call stations were systematically located in each study site to ensure even coverage. Four or five transects about 4 km long were placed along an east-west line 800 m apart. Call stations were located every 400 m along those transects, giving approximately 40 call stations in each study site. We avoided placing transects along known habitat gradients that might influence bird abundance (e.g., a riparian corridor) and thereby bias the sampling procedure (Ralph and others 1995).

Call-playback Survey

Call-playback surveys were used to estimate the relative abundance of pileated woodpeckers in two of the study sites during mating season (March 1996) and in all four study sites during nesting (May to June 1996 and 1997) and post-fledging seasons (July to August 1996 and 1997). We defined relative abundance as the response rate, or the number of responses (the number of pileated woodpeckers calling or drumming in response to a recording) divided by the number of call stations.

At each call station, a taped recording of pileated woodpecker calls and territorial drums was played at 30-s intervals using a 3-volt cassette player amplified by a battery-powered, hand-held 12-volt sound horn (Radio Shack Genexxa).[5] We used a pileated woodpecker call-playback survey methodology following protocols from British Columbia (Anonymous 1996a) and the USDA Forest Service's Pacific Northwest Research Station (Raley and Aubry 1993). Upon arriving at a call station, two field assistants would listen quietly and wait for 60-s while looking in all directions. If there was no call, or drum, or observation of a pileated woodpecker, then the entire recording of four calls and four drums was played, followed by a 5-min wait. If there was a call, drum or observation, during the initial 60-s wait or during the recording, the recording was stopped while observers watched and listened. Mid-transect responses and second responses at call stations were recorded but not included in the final data set. Mid-call station responses were disregarded because call-playback can stimulate pileated woodpeckers to follow observers or to call repeatedly. Records of second birds were eliminated to standardize the surveys as counts of potential pairs instead of counts of individual birds.

Surveys were conducted in good weather, neither on windy days (enough wind to cause leaves and twigs to be in motion: Beaufort scale 3) nor rainy days (steady rain), to maintain standard conditions for audibility and allow comparisons among surveys. We reduced observer bias by training field assistants and rotating assistants among transects. The survey period was divided into mating, nesting, and post-fledging seasons, based on observed pileated woodpecker behavior during the study, and on studies in British Columbia, Oregon, and Washington (Aubry and Raley, pers. comm.; Bull and Jackson 1995; Campbell and others 1990).

We examined how responses per call station and variability changed as number of call stations increased during a survey to determine the optimum sampling effort needed to estimate the relative abundance of pileated woodpecker. All the analyzed responses were randomized to remove seasonal and daily biases.

[5] Mention of trade names or products is for information only and does not imply endorsement by the U.S. Department of Agriculture.

Habitat Characteristics

To quantify habitat characteristics of study sites, 0.4-ha habitat circular plots (35.7-m radius) were established along 4 or 5 call-back transects in each study site: 10 plots each in Hillridge and Rithet, 19 plots in Niagara, and 20 plots in Sooke. Heterogeneous study sites were sampled at twice the effort of more homogeneous study sites. Information about each habitat plot was recorded using the Ecosystem Field Form and procedures of Ministry of Forests and Ministry of Environment (Anonymous 1996b, Luttmerding and others 1990). The variables used for analysis included volume of coarse woody debris, basal area of snags and defective trees, tree stems per hectare, structural stage, successional stage, disturbance type, and elevation. Coarse woody debris was defined as fallen trees or pieces of such trees ≥ 20 cm in diameter that were not self-supporting (fallen or suspended). Snags and defective trees were defined as dead trees ≥ 20 cm in diameter at breast height (dbh) and trees ≥ 20 cm dbh with broken tops, scars, decay, or damage, respectively. Stem density was estimated for each plot by counting all stems > 3 m tall within a 5.64-m radius circle in the center of each plot, and then multiplying by 100.

Geographical information system (GIS) data (area of study sites, forest coverages, elevation, and aspect) about the sites were compiled from digital data prepared in 1991 and 1994 from aerial photographic interpretation and fieldwork conducted in 1986 and 1988. These data were updated to include changes in forest management activities and improvements in inventory classifications according to standards of the Ministry of Forests Inventory Branch.

Statistical Analysis

Data from call-playback surveys were analysed for statistical significance by using a logistic regression model. This model was appropriate because response data (whether a pileated woodpecker responded or not) were binary. Because all habitat data were non-normal, a non-parametric Kruskal-Wallis test was used to test for the differences in the dispersion of ratio habitat data from groups of more than two samples by ranking the data (Norušis 1998, Zar 1996). A Mann-Whitney U-test was used for ratio data to determine the differences between the dispersion of two groups (Sokal and Rohlf 1981, Zar 1996). For nominal habitat data, a Chi-square cross tabulation was used to test for the hypothesis of independence of the rows and columns of a contingency table (Norušis 1998, Siegel and Castellan 1988, Zar 1996).

The level of significance utilized for table-wide comparisons was $\alpha = 0.05$. A Bonferroni correction was used for multiple comparison tests.

Results

Determination of Adequate Sample Size

The optimum sampling effort was determined from the three sites: Niagara, Sooke and Rithet *(fig. 1).* As the number of call stations reached 15 to 20 in habitats at the three study sites on southeastern Vancouver Island, the response rate and standard deviation stabilized. The steady decline of variability in mean response rate over cumulative number of call stations demonstrated that our sampling effort of ≥ 37 call stations per study area was sufficient to determine relative abundance of pileated woodpeckers. The sampling effort is probably optimal at 15-20 call stations for this type of forest in this biogeoclimatic zone.

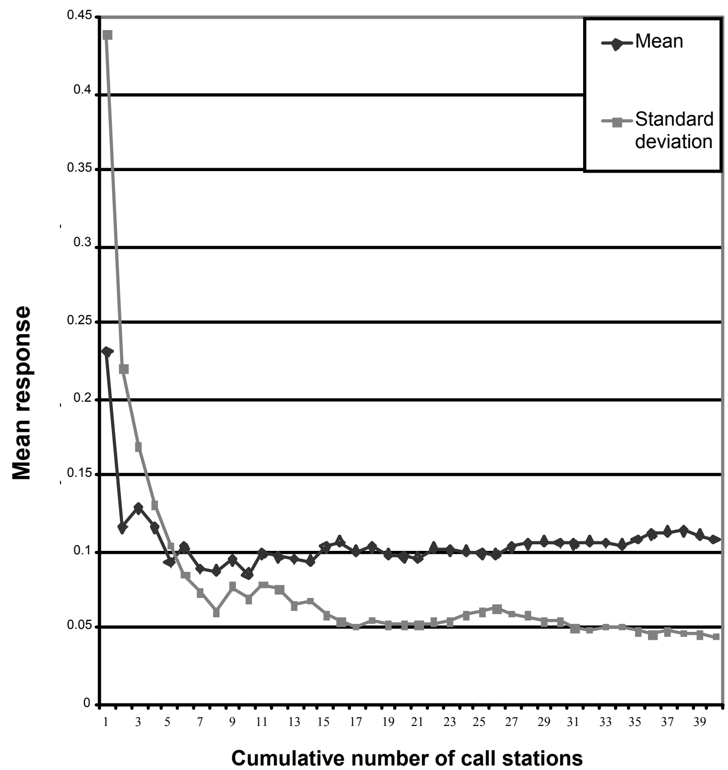

Figure 1—Mean response per call station using randomized data from 13 surveys in three pileated woodpecker study sites (Niagara, Sooke, Rithet) on southeastern Vancouver Island, 1996-1997.

Relative Abundance

A total of 16 call-playback surveys were conducted over two summers in 1996 and 1997. The lowest number of responses occurred in Hillridge: no responses in the nesting season and one response in the post-fledging season *(fig. 2)*. Niagara and Sooke had greater mean responses per call station than Hillridge. Rithet was not significantly different than Hillridge, Niagara, or Sooke. Hillridge and Rithet were not surveyed during mating season due to logistical complications (snow).

The relative abundance of pileated woodpecker differed significantly overall among the study sites and differed significantly between some study sites:

Effect or contrast of variables:	***P***
All sites: average effect	0.01
Hillridge-Niagara	<0.01
Hillridge-Sooke	<0.01
Hillridge-Rithet	0.01
Niagara-Sooke	0.19
Niagara-Rithet	0.82
Sooke-Rithet	0.18
All seasons: average effect	0.17
Mating season-nesting season	0.14
Mating season-post-fledging season	0.06
Nesting season-post-fledging season	0.52

Thus, the likelihood of receiving a response of a pileated woodpecker to a transmitted call differed among sites; overall, the effect of site was significant (*P* = 0.01). Hillridge had the lowest relative abundance, in particular, during the nesting season when pileated woodpeckers were not detected during call-playback surveys. The likelihood of receiving a response in Hillridge was significantly lower than in the other study sites. Niagara and Rithet were the least different in abundance.

Sooke had the highest mean response rate of any study site for all three seasons. However, there was no significant difference in relative abundance of pileated woodpeckers between Sooke and Niagara. Niagara and Rithet also did not differ significantly. The effect of season on the likelihood of receiving a response of a pileated woodpecker was not significant (*P* = 0.17).

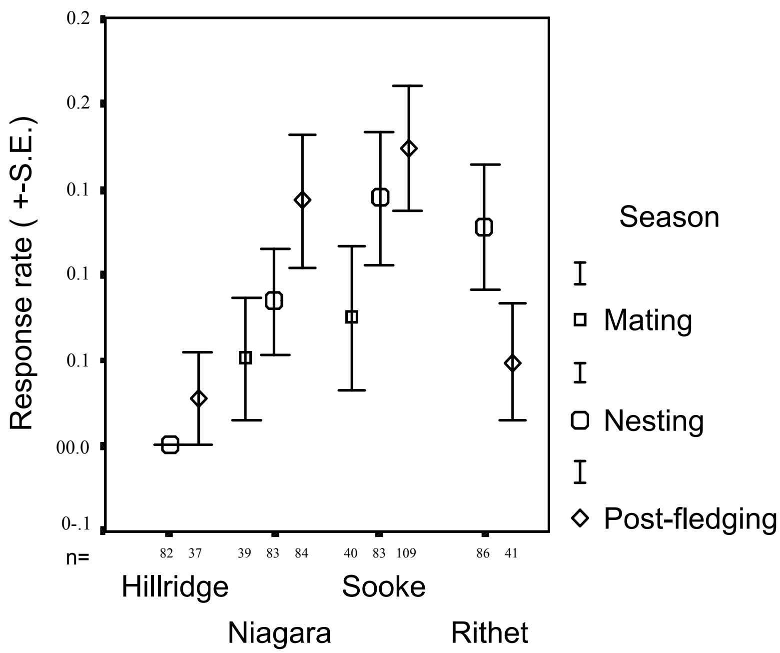

Figure 2—Relative abundance of pileated woodpecker at four study sites on southeastern Vancouver Island during three seasons, 1996-1997. Study sites are arranged from earliest to latest seral stage from left to right, n = number of call stations.

Habitat Characteristics of Study Sites

The study sites differed significantly for all habitat characteristics except coarse woody debris *(table 2)*. Coarse woody debris, however, was greater at Niagara and Sooke than at Hillridge and Rithet. Significant differences occurred for amount of snag and defective tree basal area, number of stems, structural stages, successional stage, disturbance, and elevation. The following tabulation gives the *P* values for these comparisons between areas:

	***P* values for habitat characteristics**	
Between site comparisons	**Basal area**	**Stem density**
Hillridge-Niagara	0.286	0.040
Hillridge-Sooke	<0.001	0.002
Hillridge-Rithet	<0.001	0.247
Niagara-Sooke	0.057	0.065
Niagara-Rithet	0.002	0.429
Sooke-Rithet	0.035	0.017

Although the statistical significance of differences among sites varied with individual habitat features, the four study sites can be characterized as follows. Hillridge consisted of pole/sapling and young forest structural stages, typical of mainly early seral forest. It had low amounts of coarse woody debris, a low basal area of snags, and it had the highest density of tree stems. The entire area was disturbed by logging, thinning, and spacing. Niagara was composed of several structural stages: shrub, pole/sapling, and young forest with a smaller amount of mature forest. Niagara had more seral stages than Hillridge and the coarse woody debris and basal area were greater than at Hillridge. The Niagara study site was disturbed by logging, thinning, or spacing.

Sooke had young forest, mature forest, and old forest structural stages but also had older seral stages. Amount of coarse woody debris and basal area of snags were greater than Hillridge or Niagara. Disturbance from logging was less than at Hillridge or Niagara sites. Rithet had structural stages similar to those at Sooke but with more mature and old structural stages and older seral stages. Amount of coarse woody debris was less than Niagara or Sooke, although the basal area of snags was greater than at other sites. The amount of disturbance was much less because none of the area was logged, thinned, or spaced.

Discussion

Our examination of the relative abundance of pileated woodpeckers in different seral stages has shown that there is not a direct correspondence between relative abundance and forest age. This occurs because both forest age and the quality of forest in terms of older wooden structures, both live and dead, appear to determine abundance of pileated woodpeckers. There was no significant difference in relative abundance of pileated woodpeckers among seasons, although relative abundance tended to increase in all study sites from nesting to post-fledging seasons probably because of the recruitment of juveniles. We accepted our hypothesis that landscapes with a significantly higher abundance of pileated woodpeckers have greater quantities of mature forest structures (snags, defective trees, logs).

The uniform young forest at Hillridge, < 80 years old, was not used by pileated woodpeckers during the nesting season and was used minimally during the post-fledging season. This low abundance may indicate that nesting sites were not available either within or close to Hillridge. The low abundance of pileated woodpeckers may also reflect that second-growth forests harvested before 80 years and then the cut blocks burned would likely lose old wooden structures important to pileated woodpecker, particularly for nesting. In Douglas-fir and western hemlock forests of western Oregon, the density of pileated woodpeckers was greater in forests > 80 years old than in forests < 80 years old (Nelson 1988). This suggests that intensive forest harvest that removes most residual old structures, could significantly reduce the relative abundance of pileated woodpecker for up to at least 80 years. Mannan (1984) found that pileated woodpeckers did not use forests < 40 years old for foraging and did not use forests < 70 years old for nesting.

There was no significant difference between the abundance of pileated woodpeckers in the mainly early- and mid-seral forest at Niagara and in the older forests at Sooke and Rithet. This may indicate that pileated woodpecker has some habitat flexibility in age of forest and in quality of that forest as expressed by residual old structures. This flexibility, however, should not be construed to mean that any early seral forest is acceptable habitat to pileated woodpeckers. All three study sites contained contiguous or residual patches of old forests or old forest structures. Without these late seral remnants, we expect that the abundance of pileated woodpeckers would differ among sites. On southern Vancouver Island, pileated woodpeckers do not require contiguous older forest, and their abundance is not significantly reduced in a mixed seral forest with abundant residual old wooden structures and patches of old forest (Hartwig 1999).

Although not statistically different than Niagara and Rithet, the relative abundance of pileated woodpeckers was highest in Sooke, the study site with the greatest amounts of dead wood. This suggests that the combination of large amounts of coarse woody debris, high basal areas of snags and defective trees, and low densities of stems were the most attractive habitat features to pileated woodpeckers.

The relative abundance of pileated woodpeckers at the Rithet study site decreased during the post-fledging season despite that its relative abundance during the nesting season was similar to Sooke's. The high basal areas of snags and defective trees may have provided suitable nesting sites, but the low amounts of coarse woody debris may indicate poorer foraging habitat.

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References

Anonymous. 1993. **Biogeoclimatic units of the Vancouver Forest Region, Southern Vancouver Island and Sunshine Coast.** Ministry of Forests. Victoria: Province of British Columbia; map sheet 5 of 6.

Anonymous. 1996a. **Standardized inventory methodologies for components of British Columbia's biodiversity: woodpeckers.** Victoria: Wildlife Branch, Ministry of Environment, Lands and Parks; 53 p.

Anonymous. 1996b. **Field manual for describing terrestrial ecosystem.** Ministry of Forests and Ministry of Environment. Victoria: Province of British Columbia; 108 p.

Bull, Evelyn L.; Jackson, Jerome A. 1995. **Pileated woodpecker *(Drocopus pileatus).*** In: Poole, Alan; Gill, Frank B., eds. The birds of North America No. 148. Washington, DC: The Academy of Natural Sciences, Philadelphia, Pennsylvania, and the American Ornithologists' Union; 1-24.

Bunnell, Fred L.; Wind, Elke; Boyland, Mark; Houde, Isabelle. 2002**. Diameters and heights of trees with cavities: their implications to management.** In: Laudenslayer, William F., Jr.; Shea, Patrick J.; Valentine, Bradley E.; Weatherspoon, C. Phillip; Lisle, Thomas E., technical coordinators. Proceedings of the symposium on the ecology and management of dead wood in western forests. 1999 November 2-4; Reno, NV. Gen. Tech. Rep. PSW-GTR-181. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture; [this volume].

Campbell, R. Wayne; Dawe, Neil K.; McTaggart-Cowan, Ian; Cooper, John M.; Kaiser, Gary W.; McNall, Michael C.E. 1990. **The birds of British Columbia, Volume 1, Nonpasserines.** Victoria, BC: Royal British Columbia Museum; 514 p.

Green, Robert N.; Klinka, Karel. 1994. **A field guide to site identification and interpretation for the Vancouver Forest Region.** Victoria, BC: Ministry of Forests; 285 p.

Hartwig, Carol L. 1999. **Effect of forest age, structural elements, and prey density on the relative abundance of pileated woodpecker *(Dryocopus pileatus)* on southeastern Vancouver Island.** Victoria: University of Victoria; 162 p. M.Sc. thesis.

Luttmerding, Herb A.; Demarchi, Dennis A.; Lea, Edward C.; Meidinger Del V.; Vold, Terje 1990. **Describing ecosystems in the field.** 2d ed. Victoria: Ministry of Environment, Lands and Parks and Ministry of Forests; 213 p.

Mannan, R.William. 1984**. Summer area requirements of pileated woodpeckers in western Oregon.** Wildlife Society Bulletin 12: 265-268.

Mellen, T. Kim; Meslow, E. Charles; Mannan, R. William. 1992. **Summertime home range and habitat use of pileated woodpeckers in western Oregon.** Journal of Wildlife Management 56(1): 96-103.

Nelson, S. Kim. 1988. **Habitat use and densities of cavity-nesting birds in the Oregon Coast Ranges.** Corvallis: Oregon State University; 75 p. M.Sc. thesis.

Norušis, Marija J. 1998. **Guide to data analysis.** Upper Saddle River, NJ: Prentice Hall; 563 p.

Raley, Catherine M.; Aubry, Keith B. 1993. **Protocol for pileated woodpecker call surveys and nest searches.** Olympia, WA: Pacific Northwest Research Station, Forest Service, U.S. Department of Agriculture; 7 p.

Ralph, C. John; Drogue, Sam; Saucer, John R. 1995. **Managing and monitoring birds using point counts: standards and applications.** In: Ralph, C. J.; Saucer, J. R.; Drogue, S., eds. Monitoring bird populations by point counts. Gen. Tech. Rep., PSW-GTR-149. Albany, CA: Pacific Southwest Region, Forest Service, U.S. Department of Agriculture; 161-168.

Schoener, Robert W. 1968. **Sizes of feeding territories among birds.** Ecology 49(1): 123-141.

Siegel, Sidney; Castellan N. John, Jr. 1988. **Nonparametric statistics for the behavioral sciences.** New York: McGraw-Hill Book Company; 399 p.

Sokal, Robert R.; Rohlf, F. James 1981. **Biometry, the principles and practice of statistics in biological research.** 2d ed. San Francisco, CA: W.H. Freeman and Company; 859 p.

Zar, Jerrold H. 1996. **Biostatistical analysis.** 3d ed. Upper Saddle River, NJ: Prentice-Hall Inc.; 662 p.