Habitat Selection of Northern Saw-whet Owls (*Aegolius acadicus brooksi*) on the Queen Charlotte Islands, British Columbia

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Abstract.—The Northern Saw-whet Owl of the Queen Charlotte Islands, British Columbia is recognized as a distinct subspecies, *Aegolius acadicus brooksi*. Little is known of the biology of this subspecies, and no nests have ever been found. We surveyed for Northern Saw-whet Owls on the Queen Charlotte Islands between 4 May and 28 May, 1996 establishing 10 survey routes comprising a total of 238 survey stations on Graham and Moresby Islands. Routes were chosen to maximize coverage of different forest types. We detected 61 owls and identified five trees used by singing owls. No nests were found. We used discriminant function analysis to analyze general habitat variables collected at survey stations with or without owls in order to determine habitat preferences. Sites with owls were closer to riparian habitat and had more old forest (> 120 years old) and more young forest (10-30 years old) than sites without owls. Dominant tree species at sites did not have an effect on owl detections. Three trees used by singing owls were in old forest stands and two were in mature forest stands. These trees were larger in height and diameter, and had less shrub cover around them than randomly selected trees in similar aged forests.

The Northern Saw-whet Owl of the Queen Charlotte Islands, British Columbia is recognized as a distinct subspecies, *Aegolius acadicus brooksi* (Fleming). Little is known about this distinctive taxon, particularly regarding its habitat preferences and breeding biology, and no nest has ever been found. The Northern Saw-whet Owl is a cavity nester, and Cannings (1993) suggested that the species preferred older forests where snags were common, stating that "8 of 11 calling males found on the Queen Charlotte Islands in 1987 were in small pockets of old growth Sitka spruce in large areas of second-growth forest."

Because of its restricted range, its reliance on tree cavities, its apparent preference for old or mature forests, and the general lack of information about it, this subspecies has been placed on the British Columbian Ministry of Environment's Blue List of vulnerable taxa. This study was designed to discover some basic information about the distribution, populations and habitat associations of the Queen Charlotte Northern Saw-whet Owl.

METHODS

Study Area and Site Descriptions

Queen Charlotte Islands

The Queen Charlotte Islands (fig. 1) lie about 100 km off the coast of British Columbia in a region of high rainfall (2 to 5 m annually) and moderate temperatures. The islands are covered in coniferous rainforests, with the dominant tree species being western hemlock (*Tsuga heterophylla* (Rafinesque)), western redcedar (*Thuja plicata* Donn), Sitka spruce (*Picea sitchensis* (Bongard)), lodgepole pine (*Pinus contorta* Douglas), yellow cedar (*Chamaecyparis nootkatensis* (D. Don))and red alder (*Alnus rubra* Bongard).

Survey Routes

We established 10 survey routes along roads on Graham and Moresby Islands comprising a total

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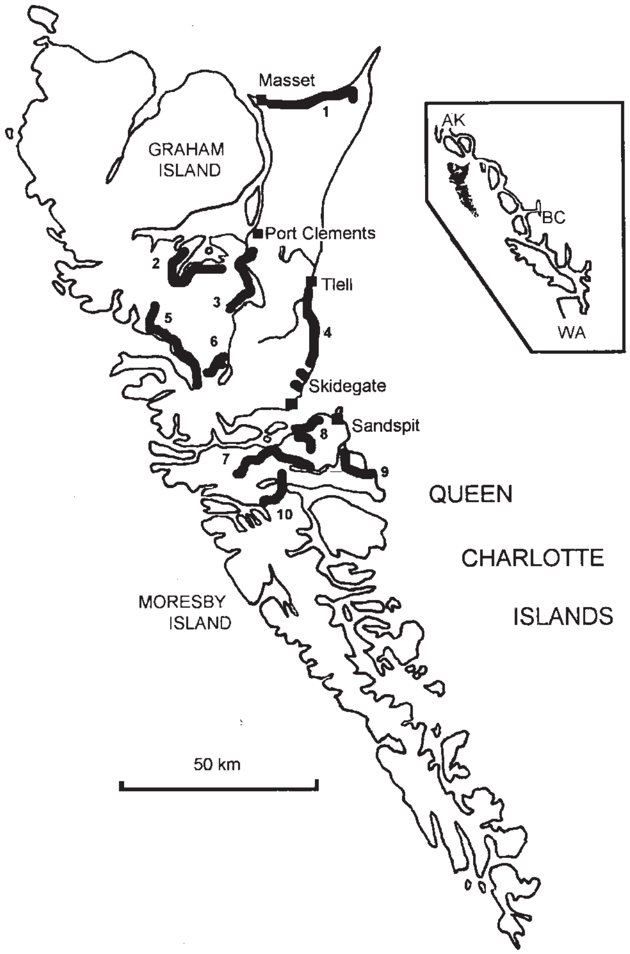

Figure 1.—*The Queen Charlotte Islands, British Columbia, showing the 10 survey routes (thick grey lines) covered in the study: 1, Tow Hill; 2, Datlamen Main; 3, Yakoun Main; 4, Tlell; 5, Rennell Sound; 6, Rennell Main; 7, Deana West; 8, Alliford Bay; 9, Gray Bay; 10, Peel Inlet.*

of 238 survey stations located 1 km apart (fig. 1). We chose survey routes in an attempt to maximize coverage of different forest stand types, biogeoclimatic subzones, and elevations. At each site we noted the following variables: elevation, biogeoclimatic subzone distance to salt water and distance to riparian zone. Within a 500-m diameter area around the survey site, we estimated the percentage cover of five different forest stand types (see below), and ranked tree species by forest cover dominance.

Forest Stand Types

We defined five categories of forest stand types (adapted from Hayward *et al.* 1993) allowing for simple translation from the different forest cover maps provided by the forest companies and the British Columbian Ministry of Forests. The five forest stand classes were:

0 Clearcut; essentially barren land; 0-10 years after initial disturbance.

1 Young forest; few or no seed producing trees, where seedling establishment is common and leaf area is increasing; 10-30 years of age.

2 Aggradation stage forest; tree establishment is significantly reduced and competition has resulted in tree mortality, but stand structure is primarily a result of the major disturbance. Trees of a single age class, new snags and few seedlings; 30-60 years of age.

3 Mature forest; mortality and regeneration are prominent processes and regeneration results from parent trees; treefall gaps and uneven tree diameter distribution; 60-120 years of age.

4 Old forest; a stand whose age and physical structure is currently influenced by processes within the stand; wide variety of tree sizes and ages and a patchy structure; 120+ years of age.

Of the total area surveyed, 17 percent was occupied by clearcuts, with 14 percent young forest, 28 percent aggradation stage forest, 18 percent mature forest, and 23 percent old forest.

Biogeoclimatic Subzones

Almost all of the Queen Charlotte Islands lie within the Coastal Western Hemlock (CWH) biogeoclimatic zone (Meidinger and Pojar 1991). Three subzones and variants (Green and Klinka 1994) occurred within the study area: 209 survey sites were in the Submontane Wet Hypermaritime subzone (CWH wh1), 4 were in the Montane Wet Hypermaritime subzone (CWH wh2), and 25 in the Rennell Sound area were in the Central Very Wet Hypermaritime subzone (CWH vh2).

Surveys

We began surveys as soon as possible after dark and continued for approximately 5 hours. We conducted the call surveys from roads, driving for 1 km, stopping, listening for 2 minutes for unsolicited song, playing a recording of owl song for 1 minute, then listening for 1 minute. The playback/listening section was repeated two more times if no owls responded to the first. If an owl was heard singing unsolicited before tape playback began, we attempted to walk into the site to locate the song tree. We mapped owl positions through triangulation whenever possible. We began the surveys on the 4th of May and completed them on the 28th of May, and surveyed all 10 routes twice. On the second survey we did not play tape recordings at sites that produced owls on the first survey. We also searched for nests in areas where owls were found.

Song Trees

We attempted to approach all owls heard singing unsolicited by our calls in order to locate the tree they were singing from (song tree). We did a more detailed habitat analysis in 20-m square plots around these trees, and compared these data with similar tree-centered plots taken at 39 randomly located trees in similar forest types. At each of these plots we collected the following data: elevation, biogeoclimatic subzone, distance to salt water, distance to riparian zone, distance to ecotone, distance to clearcut, forest stand class, slope, aspect, percent shrub coverage, dominant shrub species, canopy closure (measured with a spherical densiometer), coarse woody debris volume (estimated visually), snag density (measured along a 100 m x 20 m transect), and the species, height and diameter-at-breast-height (d.b.h.) of all trees within the plot. We also noted the species, profile (healthy, diseased, dead), height and d.b.h. of the song tree or randomly selected tree at the center of the plot.

Statistical Analysis

Survey Sites

Due to non-normal data distributions, we employed Mann-Whitney U-tests to test the equality of the mean values of the habitat measurements for survey sites with and without owls. Although each of the univariate tests can indicate Northern Saw-whet Owl habitat preferences, a multivariate analysis was used to analyze the habitat relationships as a combination of interrelated variables.

Discriminant function analysis was used to reveal the measures that had the most influence in discriminating points with and without owls (Manly 1986). Canonical discriminant function analysis using Mahalanobis distance as the selection criteria, was used to produce a discriminant function to test that function's ability in separating the two groups (SAS 1993). This function is the best linear artificial variable for separating the groups. Such an analysis requires quantitative, multivariate normal distributions with uncorrelated variables. As a result, only normally distributed, quantitative variables showing little correlation with the other variables were chosen.

A Pearson correlation was performed for all pairwise combinations of habitat variables. None of the variables were highly correlated ($r < 0.70$). As all variables were non-normal, we square-root transformed the data (SQR(X + 0.5)) in order to achieve normality for each quantitative variable. When a Pearson pairwise correlation was performed on the transformed variables, distance to salt water and elevation were strongly correlated ($r = 0.710$). As these were the only two variables to be strongly correlated, all eight of the quantitative variables (elevation, distance to salt water, distance to riparian, class 0, class 1, class 2, class 3, and class 4) were retained for the discriminant analysis.

This process resulted in eight variables remaining for the discriminant function analysis. We allowed for prior probabilities of group membership for the discriminant analysis. The equality of the discriminant scores, and thus, the effectiveness of the linear equation was determined by the Wilks' Lambda F-statistic. A cross-classification procedure (SAS 1993) using these linear discriminant equations was used to assess their accuracy in correctly classifying the survey points.

Canonical discriminant analysis produced pooled within-class standardized canonical coefficients and pooled within canonical structure coefficients. The standardized coefficient provides a measure of a variables relative contribution to the overall classification (SAS 1993). The structure coefficient determines the correlation between the variables and the function, providing a relative measure of the specific variable's ability to discriminate between the two groups (SAS 1993). To simplify the analysis, we chose variables with high standardized and structure coefficients to produce canonical discriminant functions with various combinations of these variables. These functions were then assessed for their accuracy in classifying the data. The most accurate function with the fewest number of variables was then chosen as the most effective and efficient function for separating points with and without owls.

Song Trees

We employed two sample t-tests and Mann-Whitney U-tests (Wilkinson 1992) to compare mean values of the quantitative variables with normal and non-normal distributions, respectively. As the sample size of song trees was small and, thus, power of analysis limited, multivariate analysis was not employed. Mean d.b.h. and height by tree species was calculated for each group and compared using two-sample t-tests (Wilkinson 1992). Mean number of trees per hectare by species and mean number of total stems per hectare was recorded for both groups and compared using two-sample t-tests (Wilkinson 1992).

RESULTS

We recorded 44 individual Northern Saw-whet Owls during the first round of surveys and 17 on the second round of surveys for a total of 61 individual owls. We located only five song trees and were unable to find any nests.

Owls were detected at points closer to riparian habitat with greater amounts of class 1 and class 4 forest (table 1). The other variables (elevation, distance to salt water, and amounts of class 0, class 2, and class 3 forest) did not have an influence on owl detection at the points surveyed (table 1). We detected owls with greater frequency in the CWHvh2 biogeoclimatic subzone than in the other two subzones (table 2). Neither the dominant tree species nor combinations of the two most dominant tree species had an effect on owl detections (tables 3 and 4).

Table 1.—*Comparison of means and standard errors for survey points with and without Northern Saw-whet Owls (*Aegolius acadicus*), Queen Charlotte Islands, British Columbia.*

Habitat variable[1]	Owls absent (n=188)		Owls present (n=58)		P-value[2]
	Mean	S.E.	Mean	S.E.	
Percent of Class 0	17.03	1.94	17.10	3.75	0.736
Percent of Class 1	12.30	1.99	20.30	3.86	0.078
Percent of Class 2	29.79	2.75	21.80	5.31	0.238
Percent of Class 3	19.87	2.26	10.10	4.37	0.111
Percent of Class 4	21.02	2.25	30.70	4.34	0.047
Elevation (m)	75.54	7.22	89.90	13.97	0.305
Distance to Riparian (m)	572.60	63.83	302.20	123.44	0.025
Distance to Salt Water (km)	2.36	0.22	2.45	0.43	0.468

[1] See methods for definitions.
[2] P-values are from Non-parametric Mann-Whitney U-tests (Wilkinson 1992).

Table 2.—*Mean number of Northern Saw-whet Owls (*Aegolius acadicus*) detected per survey point within each biogeoclimatic zone, Queen Charlotte Islands, British Columbia. Biogeoclimatic zone had a significant effect on owl detection (ANOVA (Wilkinson 1992), F = 4.622, N = 238, P = 0.011).*

Biogeoclimatic zone	Mean	S.E.	Sample size
CWHvh2	0.440	0.080	25
CWHwh1	0.182	0.028	209
CWHwh2	0.250	0.201	4

Table 3.—*Mean number of Northern Saw-whet Owls* (Aegolius acadicus) *detected per survey point by dominant tree species, Queen Charlotte Islands, British Columbia. Dominant tree species did not have a significant effect on owl detections (ANOVA (Wilkinson 1992), F = 0.102, N = 233, P = 0.959).*

Dominant tree	Mean	S.E.	Sample size
Sitka spruce	0.196	0.041	97
Western redcedar	0.211	0.054	57
Western hemlock	0.224	0.050	67
Red alder	0.167	0.118	12

Table 4.—*Mean number of Northern Saw-whet Owls* (Aegolius acadicus) *detected per survey point for forest dominated by different combinations of tree species, Queen Charlotte Islands, British Columbia. Pairs of dominant tree species had no effect on owl detections (ANOVA (Wilkinson 1992), F = 0.672, N = 187, P = 0.645).*

Dominant tree species (First, Second)	Mean	S.E.	Sample size
Sitka spruce, western hemlock	0.188	0.050	64
Western redcedar, western hemlock	0.250	0.063	40
Western hemlock, western redcedar	0.200	0.068	35
Western hemlock, sitka spruce	0.192	0.079	26
Western redcedar, sitka spruce	0.000	0.127	10
Sitka spruce, western redcedar	0.250	0.116	12

Discriminant function analysis of the eight quantitative, transformed variables produced a linear model which was not satisfactory in separating the groups (Wilks' Lambda F-statistic = 1.661, n = 238, P = 0.109, SAS 1993). This linear discriminant function was only able to correctly classify 59.7 percent (142 of 238) of the survey points. This function revealed that owl presence was most influenced by proportion of class 4 forest, proportion of class 1 forest, and distance to riparian habitat (table 5). A linear discriminant equation employing these three variables produced an effective linear model (Wilks' Lambda F-statistic = 4.117, P = 0.007, n = 238, SAS 1993) that was still only able to correctly classify 59.7 percent (142 of 238) of the survey points into their respective groups. Other combinations of these three variables could not produce a more effective and efficient linear model.

Tree-centered Habitat Analysis

We were able to locate only five song trees; two were in mature forest and three were in old forest. To narrow our comparison, we restricted our randomly sampled trees to mature and old forests. Owl song trees were associated with significantly lower shrub coverage and a greater canopy closure than generally found in class 3 and class 4 forests (table 6). Owls were selecting song trees that were greater in height and d.b.h. than what is generally available in these forests (table 6). Song trees were found in areas with significantly smaller-diameter western redcedar and with taller western hemlocks than what was usually found in these forests (table 7 and 8). Although total tree densities did not differ surrounding song trees and random trees, there were significantly lower densities of Sitka spruce trees surrounding song trees (table 9). Song tree species and profile were not significantly different from those of randomly-selected trees.

DISCUSSION

The results from the habitat analysis of survey sites show an interesting combination of habitat associations for Queen Charlotte Northern Saw-whet Owls, that of older forests next to very young forests. Old forests may be attractive to

*Table 5.—Standardized coefficients produced by canonical discriminant function analysis for points with and without Northern Saw-whet Owls (*Aegolius acadicus*), Queen Charlotte Islands, British Columbia.*

Discriminant function variable	Structure coefficient	Standardized coefficient
Elevation	0.266	-0.071
Distance to riparian	-0.602	-0.558
Distance to salt water	0.136	-0.056
Class 0	0.066	0.516
Class 1	0.495	0.946
Class 2	-0.312	0.458
Class 3	-0.479	0.412
Class 4	0.542	0.975

Table 6.—*Comparison of means and standard errors for Northern Saw-whet Owls (*Aegolius acadicus*) song trees and randomly selected trees, Queen Charlotte Islands, British Columbia.*

Habitat variable	Singing trees			Random trees			P-value
	Mean	S.E.	N	Mean	S.E.	N	
Elevation (m)	84.0	32.8	5	71.5	14.3	39	0.741[1]
Distance to salt water (km)	5.3	4.8	5	14.7	12.8	39	0.052[2]
Distance to riparian (m)	127.0	32.5	5	433.3	125.3	39	0.985[2]
Distance to ecotone (m)	196.0	87.2	5	331.9	80.7	39	0.273[1]
Distance to clearcut (m)	406.0	171.1	5	3,899.8	1,271.7	33	0.476[2]
Slope (deg)	6.0	6.0	5	7.2	2.0	39	0.569[2]
Aspect (deg)	244.0	—	1	168.5	28.2	14	n/a
Shrub coverage (percent)	0.4	0.2	5	30.5	6.3	39	0.016[2]
Canopy closure (percent)	98.8	0.6	5	93.3	1.5	39	0.002[1]
Coarse woody debris vol (m^3)	12.8	2.3	5	12.0	1.4	39	0.775[1]
Snag density (1/ha)	34.4	3.9	5	33.9	3.7	39	0.934[1]
Tree height (m)	48.2	8.0	5	23.7	1.8	39	0.037[1]
Tree d.b.h. (cm)	167.7	32.8	5	44.0	4.0	39	0.019[1]

[1] P-values resulting from two-sample t-tests with separate variances.
[2] P-values resulting from non-parametric Mann-Whitney U-tests (Wilkinson 1992).

Table 7.—*Mean diameter of each tree species found within random and Northern Saw-whet Owls (*Aegolius acadicus*) song tree plots, Queen Charlotte Islands, British Columbia.*

Tree species	Singing tree plots			Random plots			P-value[1]
	Mean	S.E.	N	Mean	S.E.	N	
Lodgepole pine	36.8	2.7	4	45.3	8.2	4	0.386
Red alder	—	—	—	33.9	3.0	16	n/a
Sitka spruce	49.1	5.3	6	38.1	1.9	152	0.097
Western hemlock	35.9	2.3	56	32.0	1.0	294	0.137
Western redcedar	32.9	3.0	8	46.0	2.1	184	0.003
Yellow cedar	—	—	—	37.1	4.7	27	n/a

[1] P-values resulted from two-sample t-tests with separate variances (Wilkinson 1992).

Table 8.—*Mean height for each tree species found within random and Northern Saw-whet Owls (*Aegolius acadicus*) song tree plots, Queen Charlotte Islands, British Columbia.*

Tree species	**Singing tree plots**			**Random plots**			**P-value**[1]
	Mean	**S.E.**	**N**	**Mean**	**S.E.**	**N**	
Lodgepole pine	31.8	1.7	4	29.3	0.9	4	0.249
Red alder	—	—	—	18.8	1.6	16	n/a
Sitka spruce	33.8	3.3	6	27.4	0.8	152	0.109
Western hemlock	26.8	1.2	56	22.3	0.6	294	0.001
Western redcedar	24.9	1.7	8	24.6	0.7	184	0.896
Yellow cedar	—	—	—	21.0	1.4	27	n/a

[1] P-values from two-sample t-tests with separate variances (Wilkinson 1992).

Table 9.—*Mean number of trees by species per hectare, measured from plots around five Northern Saw-whet Owls (*Aegolius acadicus*) song trees and 39 randomly selected trees in similar forest types, Queen Charlotte Islands, British Columbia.*

Tree species	**Singing tree**		**Random tree**		**P-value**[1]
	Mean	**S.E.**	**Mean**	**S.E.**	
Lodgepole pine	20.0	20.0	2.6	1.5	0.433
Red alder	0.0	0.0	10.3	3.8	n/a
Sitka spruce	30.0	15	97.5	25.0	0.023
Western hemlock	280.0	58.8	182.1	22.0	0.139
Western redcedar	40.0	34.1	117.9	29.8	0.111
Yellow cedar	0.0	0.0	17.3	7.5	n/a
Total stems	375.0	51.2	429.5	40.8	0.424

[1]P-values resulting from two-sample t-tests using separate variances.

the owls, since they need cavities for nesting and an open understory for hunting. Young forests may provide good roosting habitat, since this species roosts in thick vegetation, either near the ends of branches on large trees or near the trunks of small, densely growing trees (Cannings 1993). It is difficult to explain the high frequency of owl encounters in the CWH vh2 biogeoclimatic subzone. Only 25 survey sites, all on one survey route, were in this sub-zone, so other factors working at a larger scale could have affected owl numbers there.

The finding that song trees were relatively close to salt water might be due to some unknown topographic variable, such as the frequency of canyons that might have prevented us from reaching song trees in areas farther from the sea. Data from song trees did not support the survey results that owls were associated with riparian zones. The fact that song trees were significantly larger than randomly selected trees would suggest that the owls might be using high song posts to broadcast their songs as far as possible through the dense forests. Although the sample size for song trees is low, the variances on the measurement means were small, indicating that this was a habitat feature the owls were selecting.

While the results of this study identify habitat associations of Northern Saw-whet Owls on the Queen Charlotte Islands, there are several factors that may have affected the results. One is the time of year the surveys were done. The seasonal phenology of owl activity on the Queen Charlottes is poorly known. Conducting surveys in March or April, when owl singing activity peaks in other parts of the species' range (Cannings 1993), might increase the number of owl encounters as well as reduce the chance that birds encountered were those in suboptimal habitat that had been unable to attract mates early in the season.

Finding song trees depended on getting to them promptly in the dark. The main reasons for not reaching some were the presence of deep canyons and early cessation of song.

Perhaps the biggest bias facing the data analysis and interpretation is that of depending on playback response to get habitat association data in a patchy environment. The Queen Charlotte Islands is covered with a patchwork of forest stand types, the result of clearcut logging practices over the last few decades. The habitat mix within 500 m of a survey site may not accurately represent the habitat types used by birds called into that site. Our plans to find unsolicited singing locations were designed to avoid this problem, as was done for Boreal Owls (Herren *et al.* 1996). Unfortunately this was difficult and data were too few to perform a useful multivariate analysis.

There is still a need for more research on this topic. Field work should begin in late March or early April, and should concentrate on finding song trees and nest sites. Radio telemetry would provide more accurate data on this owl's habitat needs.

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LITERATURE CITED

Cannings, Richard J. 1993. Northern Saw-whet Owl, In: Poole, A.; Stettenheim, P.; Gill, F., eds. The birds of North America, No. 42. Philadelphia, PA: The Academy of Natural Sciences; Washington, DC: The American Ornithologists' Union.

Green, R.N.; Klinka, K. 1994. A field guide to site identification and interpretation for the Vancouver Forest Region. Victoria, BC: British Columbian Ministry of Forests, Research Program. 285 p.

Hayward, G.D.; Hayward, P.H.; Garton, E.O. 1993. Ecology of Boreal Owls in the northern Rocky Mountains, USA. Wildlife Monographs. 124.

Herren, Vicki; Anderson, Stanley H.; Ruggiero, Leonard F. 1996. Boreal Owl mating habitat in the northwestern United States. Journal of Raptor Research. 30: 123-129.

Manly, B.F.J. 1986. Multivariate statistical methods - a primer. New York, NY: Chapman and Hall. 159 p.

Meidinger, Del; Pojar, Jim. 1991. Ecosystems of British Columbia. Victoria, BC: British Columbian Ministry of Forests. 330 p.

SAS Institute. 1993. SAS/ETS user's guide: version 6. Cary, NC: SAS Institute. 1,022 p.

Wilkinson, L. 1992. Systat for Windows: statistics, version 5 ed. Evanston, IL: Systat, Inc. 750 p.