Does Habitat Matter in an Urbanized Landscape? The Birds of the Garry Oak (*Quercus garryana*) Ecosystem of Southeastern Vancouver Island[1]

Richard E. Feldman[2] and Pamela G. Krannitz[3]

Abstract

Garry oak (*Quercus garryana*) was once a dominant habitat type on southeastern Vancouver Island, British Columbia but urbanization has severely fragmented and reduced its occurrence. This study tests whether bird abundance in remnant patches of Garry oak and adjacent Douglas-fir (*Pseudotsuga menziesii*) is related to Garry oak volume, patch size or urbanization. Breeding bird populations were surveyed at seven Garry oak sites and four adjacent Douglas-fir sites. Relationships between environmental variables and abundance of 17 species of birds were inferred by selecting the best linear regression model by Akaike Information Criterion. For five species, the best model included Garry oak volume, two species being positively related to oak habitat and three species preferring Douglas-fir habitat. Eight species were associated more with patch size or level of urbanization in the surrounding landscape. For these species, the effects of fragmentation overwhelmed the importance of habitat differences. While habitat degradation of remnant patches is a conservation issue, the bird community of this urbanizing landscape would most benefit if human modification of the surrounding landscape was reduced.

Introduction

Southeastern Vancouver Island, British Columbia, is an urban region with two dominant terrestrial ecosystems: Garry oak (*Quercus garryana*) parkland and Douglas-fir (*Pseudotsuga menziesii*) forest. Each provides different resources to wildlife and is expected to support different wildlife communities. The Garry oak ecosystem, for example, has an open canopy of Garry oak with a grassy understory (Erickson 1996). Douglas-fir dominated forest, on the other hand, has a closed canopy. Grass is nearly absent from the understory, which is dominated by salal (*Gaultheria shallon*) and sword fern (*Polystichum munitum*) (Feldman, personal observation).

The Garry oak ecosystem is considered endangered and there are many at-risk flora and fauna associated with Garry oak habitat (Erickson 1993). The major threats

---

[1] An abbreviated version of this paper was presented at the Fifth Symposium on Oak Woodlands: Oaks in California's Changing Landscape, October 22-25, 2001, San Diego, California

[2] M.Sc. candidate, Centre for Applied Conservation Research, University of British Columbia, 3rd floor, Forest Sciences Centre, 2424 Main Mall, Vancouver, BC V6T 1X6 (e-mail address: richaref@interchange.ubc.ca)

[3] Research Scientist, Canadian Wildlife Service, 5421 Robertson Rd., RR #1, Delta, BC V4K 3N2 (e-mail: pam.krannitz@ec.gc.ca)

to the Garry oak ecosystem are habitat loss, fragmentation and invasion by exotic species. The center of British Columbia's Garry oak is located in what is now the city of Victoria. The greater area has a population of 304,287 and is growing at an annual rate of 5.7 percent (Statistics Canada 1999). Estimates put Garry oak ecosystem loss at between 95 percent and 99 percent since European colonization of the area (Hebda 1993). Consequently, Garry oak habitat is limited to small, remnant patches often surrounded by development.

This study uses the Garry oak ecosystem to test whether the unique habitat features of an ecosystem matter to birds in the face of extensive urbanization. This is done by comparing the abundances of bird species between Garry oak and Douglas-fir fragments of varying sizes and of varying land-use contexts. If habitat matters, then abundance should be related to habitat type instead of landscape factors. If urbanization is too extensive, patch size or level of urbanization in the landscape instead shapes site selection. In addition, we test whether Douglas-fir patches surrounding Garry oak have an influence on bird population size within Garry oak. A positive relationship indicates that Douglas-fir patches can act as a buffer to urbanization.

Methodology

Study Sites and Experimental Design

We used the Sensitive Ecosystem Inventory (Canadian Wildlife Service 1997) to select sites with the following criteria: 1) patches classified as being dominated by Garry oak; 2) patches larger than 4 ha, and 3) sites that are easily accessible. This resulted in the selection of seven sites along an urban-rural gradient emanating from the core of Victoria *(fig. 1)*. Sites differed in size and level of development in the surrounding landscape as measured by human population density *(table 1)*. Four of the seven Garry oak sites were surrounded by Douglas-fir forest, while three were surrounded by residential development. Bird communities were surveyed in Garry oak and Douglas-fir habitat patches.

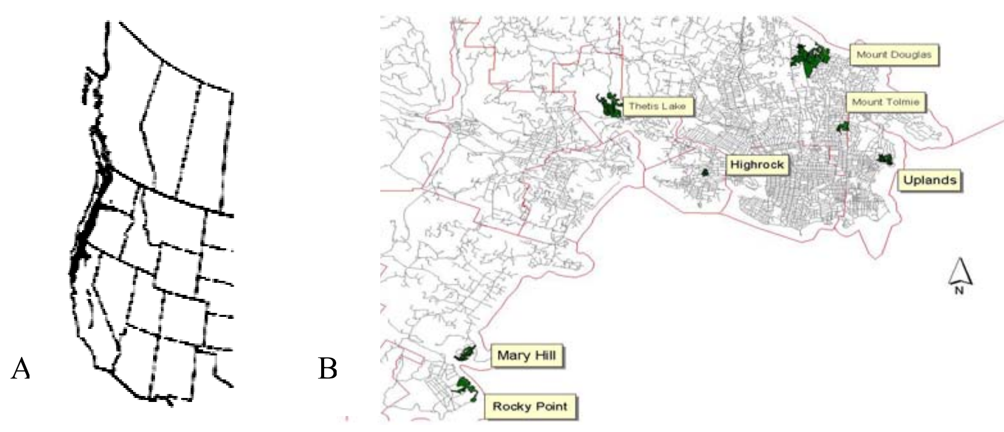

Figure 1—The study area: A) The Garry oak ecosystem (darkened area) ranges from California to British Columbia. B) Seven Garry oak patches were chosen for this project. Rocky Point, Mary Hill, Thetis Lake and Mt. Douglas patches were adjacent to Douglas-fir forest, while the remaining three were completely surrounded by city. Bird surveys were conducted in both the Garry oak and Douglas-fir habitats.

Table 1—*Environmental characteristics of each site.*

Site	Garry oak volume (m^3/ha)		Patch size (ha)		Human population density (/km^2)
Habitat type →	Garry oak	Douglas-fir	Garry oak	Douglas-fir	
Mount Douglas	34.76	0	21.21	52.6	1,041.87
Mary Hill	107.31	6.41	9.85	120.57	302.11
Rocky Point	285.31	3.37	9.40	22.25	302.11
Thetis Lake	17.47	1.45	6.56	44.56	545.13
Highrock Cairn	17.19	-	6.60	-	2,809.36
Mount Tolmie	24.42	-	17.97	-	2,344.88
Uplands	31.52	-	23.03	-	1,054.24

Bird Surveys

At each site, bird surveys were conducted along two parallel transects separated by 100 m. The transects were placed to maximize the length of the patch while avoiding edges. All transects were 400 m in length except Rocky Point and the Douglas-fir portion of Mount Douglas (350 m) and Highrock (250 m). Bird survey points were placed every 50 m along the transect.

Bird surveys were conducted between dawn and three hours after dawn from 5 May to 30 June 2000. During the survey, the observer walked the transect (starting point randomized) and stopped at each observation point. All birds seen and heard in 5 min. within a 50-m radius of the point were recorded on a map of the site. Five visits were made to Mary Hill, Rocky Point, Mount Douglas and Thetis Lake, while the remaining sites were visited four times. Visits to the same site were separated by at least five days.

Upon completion of the breeding surveys, the number of territories for each species at each site was determined by finding clusters of at least two observations from separate survey dates in approximately the same location on the map (i.e. territory-mapping method; Bibby and others 1992). The number of territories for each species was converted to a density value by dividing by the area surveyed. Of all the birds recorded, selected species were used in analyses based on: 1) appropriateness of the territory mapping method as an indicator of abundance (flocking species excluded), 2) frequency of occurrence (birds in fewer than five patches excluded), and 3) expected habitat relationship. The latter requirement was used to separate generalist species from those that are likely to differ in abundance between Garry oak and Douglas-fir habitat. Habitat use was derived from a study of Oregon's Garry oak and conifer habitats (Anderson 1972) and a study comparing grassland, open patches and Douglas-fir forests in the interior of BC (Schwab and Sinclair 1994). Seventeen species were used to make inferences regarding avian habitat selection. Based on the literature, nine species were expected to be relatively more abundant in Garry oak habitat, while eight species were expected to be associated with Douglas-fir patches. Overall species richness among sites was also analyzed for its relationship with the environmental variables.

Environmental Measures

Tree measurements were made along 50-m transects that ran perpendicular to the bird survey transects at each bird survey point. All oaks greater than 2 m in height and 5 cm in diameter within 5 m of each side of the transect were counted. Diameter at breast height and height were measured on five randomly chosen individuals.

Stem volume of Garry oak per hectare was determined in each site. This volume measure combines height and diameter at breast height via the following equation, developed for bigleaf maple trees (B.C. Forest Service 1983):

$$\log \text{volume} = -4.536696 + 1.907850 \log \text{diameter} + 1.120160 \log \text{height}$$

This measure was determined for each oak surveyed, averaged and multiplied by tree density to obtain a volume/ha measurement for each site. Stem volume was a surrogate for habitat type. Douglas-fir patches were expected to have little or no Garry oak.

Patch size was taken from the Sensitive Ecosystem Inventory GIS database (Canadian Wildlife Service 1997). The area of all the continuous polygons of one habitat type (Garry oak or Douglas-fir) were summed to derive overall patch area. Douglas-fir patch size was also used as the measure of buffer size since these patches surrounded Garry oak patches.

The 1996 Canada census was used to assess the human population in the census tract in which each site was located (Statistics Canada 1999). Since census tract area varied, population was divided by area to obtain a density measurement.

Data Analysis

The ultimate goal of this project was to make inferences regarding how the pattern of abundance of different species found in remnant patches related to variation in habitat and landscape factors. We developed a series of linear regression models consisting of one or more predictor variables: Garry oak volume, patch size, Douglas-fir buffer size, and human population density. In addition, we included a null model that relates a species' abundance to its mean and variance and describes the situation in which no discernable pattern in abundance is found.

The series of models represent multiple research hypotheses. For each species and overall species richness, the models are ranked based on how well each approximates the pattern in bird abundance data. The criterion for ranking is the Akaike Information Criterion (AIC; Burnham and Anderson 1998). Due to low sample size, an AIC variant, AICc, was used as the final measure. AIC/AICc is an objective way of finding the most parsimonious model of the pattern of bird abundance across fragments, given the parameters measured (Burnham and Anderson 1998). The model used for inferring a bird abundance-environmental variable relationship was most often the model with the lowest AICc (i.e. $\Delta = 0$, where Δ is the difference between a model's AICc and the lowest AICc). However, due to model selection uncertainty (i.e., the confidence that the model would be chosen with other data sets generated under the same conditions), model weighting and parameter importance (expressed as the sum of weights of models in which the variable appears) were also used to select the final model (Burnham and Anderson 1998). The above procedure was conducted on each of the 17 species and for species richness.

Results

Table 2 details the three best approximating models for each species and for species richness. For most species the model with the least AICc was used for inference. For brown-headed cowbird and northern flicker, however, model selection uncertainty was high and more than one model could be used for inference (i.e., Δ<1.0). In these cases, the most parsimonious model with the most important variable was chosen as the best model.

Of the 18 final models, only three involved more than one environmental variable *(table 2)*. Two species responded positively to oak volume, while three showed preferences for Douglas-fir habitat. Seven species chose territories irrespective of habitat type and were more affected by patch size or level of urbanization. For two species, the house wren (*Troglodytes aedon*) and Wilson's warbler (*Wilsonia pusilla*), each single variable model performed equally as well. Consequently, one final model could not be used for inference. The null model was the best approximating model for Bewick's wren (*Thryomanes bewickii*), spotted towhee (*Pipilo maculatus*), pacific-slope flycatcher (*Empidonax dificilis*), and overall species richness. Territory density of these species and species richness across fragments was random and could best be explained by population mean and variance.

Table 2—*The top 3 linear regression models relating bird territory density to environmental variables as chosen by AICc. Terms used in the final model have a positive (+) or negative (-) relationship with bird territory density.*

Best approximating models	K[1]	AICc	ΔAICc	weight	parameter importance	relationship
Anna's hummingbird						
human pop. density	3	-28.95	0	0.23	0.55	-
area + human pop. density	4	-27.13	1.82	0.09		
area	3	-27.01	1.94	0.09		
Bewick's wren						
null	2	-13.93	0	0.33		
oakvol + human pop density	4	-11.93	2.00	0.12		
human pop density	3	-11.77	2.16	0.11		
brown-headed cowbird						
oakvol + doug. fir + human pop density	5	-27.04	0	0.26	oakvol 0.98	
oakvol	3	-26.84	0.20	0.24		+
oakvol + doug. fir	4	-26.45	0.59	0.20		
brown creeper						
oakvol	3	-16.47	0	0.25	0.47	-
oakvol + area	4	-16.24	0.23	0.22		
area	3	-15.93	0.54	0.19		
chestnut-backed chickadee						
human pop density	3	-24.11	0	0.46	0.60	-
oakvol	3	-22.49	1.62	0.21		
area + human pop. density	4	-21.66	2.45	0.14		
chipping sparrow	4					
oakvol + doug. fir	4	-48.46	0	0.41	0.59	oakvol + doug. fir +

Table 2 continued

Best approximating models	K[1]	AICc	ΔAICc	weight	parameter importance	relationship
oakvol + doug. fir + human pop. density	5	-46.90	1.56	0.19		
doug. fir	3	-46.32	2.15	0.14		
dark-eyed junco						
human pop. density	3	-21.02	0	0.53	0.73	-
area + human pop. density	4	-19.00	2.02	0.19		
null	2	-17.36	3.66	0.09		
golden-crowned kinglet						
oakvol	3	-17.71	0	0.42	0.54	-
null	2	-15.64	2.07	0.15		
human pop. density	3	-15.30	2.40	0.13		
house wren[2]	4					
doug. fir	3	-30.51	0	0.19	0.43	+
human pop. density	3	-30.14	0.37	0.16	0.41	-
area	3	-29.68	0.83	0.12	0.35	-
oakvol	3	-29.28	1.22	0.10	0.30	+
northern flicker						
oakvol + area + human pop. density	5	-45.41	0	0.42	oakvol 0.44 area 0.96 human 0.96	
area + human pop. density	4	-45.33	0.08	0.40		area – human -
area + doug. fir + human pop. density	5	-42.86	2.55	0.12		
orange-crowned warbler	4					
doug. fir + human pop. density	4	-23.53	0	0.26	0.37	doug. fir + human -
area + doug. Fir	4	-22.52	1.01	0.16		
area + doug. fir + human pop. density	5	-21.83	1.69	0.11		
pacific-slope flycatcher						
null	2	-11.58	0	0.83		
oakvol	3	-6.09	5.49	0.05		
human pop. density	3	-5.99	5.59	0.05		
red-breasted nuthatch						
area	3	-44.43	0	0.48	0.96	+
area + human pop. density	4	-43.43	1.00	0.29		
oakvol + area	4	-42.54	1.89	0.19		
spotted towhee	4					
null	2	-6.31	0	0.25		
human pop. density	3	-6.22	0.09	0.24	0.64	
area + human pop. density	4	-4.68	1.63	0.11		
Townsend's warbler						
human pop. density	3	-29.28	0	0.67	0.87	-
area + human pop. density	4	-26.92	2.35	0.21		

Table 2 continued

Best approximating models	K[1]	AICc	ΔAICc	weight	parameter importance	relationship
oakvol	3	-24.37	4.91	0.06		
Wilson's warbler[2]	4					
doug. fir	3	-25.83	0	0.20	0.45	+
oakvol	3	-25.26	0.57	0.15	0.36	+
human pop. density	3	-24.82	1.01	0.12	0.31	-
area	3	-24.71	1.12	0.11	0.34	+
winter wren						
oakvol	3	-14.41	0	0.34	0.48	-
null	2	-13.73	0.68	0.25		
area	3	-12.68	1.73	0.15		
species richness						
null	2	20.32	0	1		
human pop. density	3	65.56	45.24	1.5E-10		
oakvol + human pop. density	4	67.93	47.61	4.59E-11		

1 Number of parameters.
2 These species have four equally likely single variable models. A final model could not be chosen for inference.

Discussion

Only two species favour Garry oak habitat over Douglas-fir forest. The brown-headed cowbird (*Molothrus ater*) is avoiding the closed-canopy forest and selecting for oak habitat. The chipping sparrow (*Spizella passerina*) is also selecting for Garry oak habitat. Unlike the cowbird, it is restricted to those oak patches surrounded by Douglas-fir forest, thus showing a response to surrounding habitat. The chipping sparrow may be the only species for which the Garry oak ecosystem is a vital component for its persistence in the region. Further studies on chipping sparrow use and productivity in other open-habitats are needed to test this claim.

Although a community of oak-associated species is not currently present, a small Douglas-fir forest community existed. Three species (winter wren [*Troglodytes troglodytes*], brown creeper [*Certhia americana*] and golden-crowned kinglet [*Regulus satrapa*]) showed preference for Douglas-fir forest patches. These species are associated with conifer forests in other Pacific Northwest landscapes (Anderson 1972, McGarrigal and McComb 1995, Schwab and Sinclair 1994).

Urbanization factors, rather than patch type, were related to population size for the majority of the species analyzed. The red-breasted nuthatch (*Sitta canadensis*) and northern flicker (*Colaptes auratus*) had population size best modeled by the patch size variable. The former was limited to larger patches, while the flicker had higher populations in smaller patches. That so few species responded to patch size is surprising. Patch area was shown to be the largest influence on species richness and population size of over half of the species studied in other urbanized and fragmented woodlands (Blake and Karr 1987, Tilghman 1987).

Human population density—an indicator of urbanization in the landscape—was correlated to population size for five species (orange-crowned warbler [*Vermivora celata*], chestnut-backed chickadee [*Parus rufescens*], dark-eyed junco [*Junco hyemalis*], Townsend's warbler [*Dendroica townsendi*] and Anna's hummingbird

[*Calypte anna*]). Since four of these species are absent or in low numbers from highly urbanized patches, further urbanization of southeastern Vancouver Island may negatively impact these species. Even if loss of habitat itself is minimal, changes to the landscape surrounding Garry oak and Douglas-fir patches will introduce new predators, create hard edges and disrupt population processes such as immigration and dispersal (Saunders and others 1991). The influence of the surrounding landscape on populations within patches has been shown in other studies, including one from oak woodlands in California (Sisk and others 1997).

Management Implications

For most species, resource differences in Garry oak and Douglas-fir habitat are not reflected in population size. It is when the landscape around these patches becomes degraded that the habitat loses its value. Therefore, the most important management activity to maintain healthy bird communities is to minimize development around the patches. Site-level management would have some value. For example, maintaining open-oak habitat may benefit chipping sparrow. Preventing further habitat loss by restoring and conserving all remnants should be the priority for ensuring population persistence of southeastern Vancouver Island's birds. Considering that most birds in the region use both Garry oak and Douglas-fir habitat, these ecosystems should be managed together at the landscape scale.

Acknowledgments

This project was funded by the Georgia Basin Ecosystem Initiative of Environment Canada. Access to sites was provided by the Saanich, Oak Bay, Esquimalt and Capital Regional District parks departments. Access to Mary Hill and Rocky Point was provided by Art Robinson and Gordon Usipck of the Canadian Forest Service and Department of National Defence. Thank you to Katie Christie for her tremendous help with field work in 2000. This project is dedicated to all those volunteering their time to restore and conserve British Columbia's Garry oak ecosystem.

References

Anderson, S. H. 1972. **Seasonal variations in forest birds of western Oregon**. Northwest Science 46: 194-206.

Bibby, C. J.; Burgess, N. D.; Hill, D. A. 1992. **Bird Census Techniques**. San Diego: Academic Press.

Blake, J. G.; Karr, J. R. 1987. **Breeding birds of isolated woodlots: area and habitat relationships.** Ecology 68: 1724-1734.

British Columbia Forest Service 1983. **Whole stem cubic metre volume equations, 1976**. In: Watts, S. B., ed. Forestry Handbook for British Columbia. 4th ed. Vancouver: Forestry Undergraduate Society.

Burnham, K. P.; Anderson, D. R. 1998. **Model selection and inference: a practical information-theoretic approach**. New York: Springer.

Canadian Wildlife Service 1997**. Sensitive Ecosystem Inventory: East Vancouver Island and Gulf Islands. Select Version 2**. Qualicum Beach: Environment Canada.

Erickson, W. R. 1993. **Garry oak ecosystems**. Ecosystems at Risk Brochure. Victoria: BC Ministry of Environment, Lands and Parks.

Erickson, W. R. 1996. **Classification and interpretation of Garry Oak plant community communities and ecosystems in southwestern British Columbia**. Victoria: University of Victoria. MSc thesis.

Hebda, R. J. 1993. **Natural history of the Garry Oak**. In: Proceedings of the Garry oak-meadow colloquium. Hebda, R.J.; Aitkens, F., eds. Victoria; 3-7.

McGarigal, K.; McComb, W. C. 1995. **Relationships between landscape structure and breeding birds in the Oregon coast range.** Ecological Monographs 65: 235-260.

Saunders, D. A.; Hobbs, R. J.; Margules, C. R. 1991. **Biological consequences of ecosystem fragmentation: a review.** Conservation Biology 5: 18-32.

Schwab, F. E.; Sinclair, A.R.E. 1994. **Biodiversity of diurnal breeding bird communities related to succession in the dry Douglas-fir forests of southeastern British Columbia.** Canadian Journal of Forest Research 24: 2034-2040.

Sisk, T. D.; Haddad, N. M.; Ehrlich, P. R. 1997. **Bird assemblages in patchy woodlands: modeling the effects of edge and matrix habitats.** Ecological Applications 7: 1170-1180.

Statistics Canada 1999. **Profile of census divisions and subdivisions in British Columbia.** Statistics Canada catalogue #95-191-XPB

Tilghman, N. G. 1987. **Characteristics of urban woodlands affecting breeding bird diversity and abundance.** Landscape and Urban Planning 14: 481-495.