Bird Communities of the Garry Oak Habitat in Southwestern British Columbia

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Identifying the bird communities of a habitat could contribute to conservation efforts and provide benchmarks for ecosystem studies. Garry Oak (*Quercus garryana)* ecosystems in British Columbia are among the most endangered in Canada and warrant conservation. Four bird communities were determined by analyzing an extensive sample of Garry Oak habitat bird data. These communities were defined objectively by aggregations of the bird species themselves from across the various sites and areas. Characteristic species of these communities include American Goldfinch (*Carduelis tristis*), Spotted Towhee (*Pipilo maculatus*), Bewick's Wren (*Thryomanes bewickii*), Rufous Hummingbird (*Selasphorus rufus*) and Chestnut-backed Chickadee (*Poecile rufescens*) in community 1; House Wren (*Troglodytes aedon*), Olive-sided Flycatcher (*Contopus cooperi*), Purple Finch (*Carpodacus purpureus*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Pine Siskin (*Carduelis pinus*) in community 2; Western Tanager (*Piranga ludoviciana*), Yellow-rumped Warbler (*Dendroica coronata*), American Goldfinch, Pine Siskin, Pacific-slope Flycatcher (*Empidonax difficilis*), Cassin's Vireo (*Vireo cassinii*) and Chipping Sparrow (*Spizella passerina*) in community 3; and Northwestern Crow (*Corvus caurinus*) and European Starling (*Sturnus vulgaris*) in community 4. Differences between the communities are suggested from the life history traits of the species, including a community consisting mostly of insectivores when on breeding territory (number 1), one with species foraging primarily in shrubs and trees (community 3), and another with tree-nesting ground gleaners (number 4). One community (number 3) had analogues in two widely disparate areas: oak-associated in north-central New Mexico, and aspen (*Populus tremuloides*)-related in northcentral British Columbia; otherwise communities reported in the literature were generally not directly comparable.

Key Words: bird communities, Garry Oak, *Quercus garryana*, multivariate classification, British Columbia.

Garry Oak, *Quercus garryana* habitat is unique within Canada, and related biogeographically to California (Erickson 1996). Garry Oak ecosystems are at their northern margin in British Columbia, and are among the most endangered ecosystems in Canada (Erickson 1993*, 2000a). Native stands have been reduced by urban development and are threatened with invasion by alien species. Bird communities of Garry Oak habitat in the Pacific Northwest have not yet been fully investigated. Defining these communities is a basic step toward conservation, and a requisite to identifying critical habitat requirements. Predictive abilities and assessments for preservation and management of the Garry Oak habitat could be strengthened by further understanding these communities.

Garry Oak occurs in an area of southwestern British Columbia with a distinctive modified mediterranean climate in the strong rain-shadow of the Olympic and Vancouver Island mountains. Mild, wet winters, variable precipitation and regular summer drought are typical. The result on the landscape is a mosaic of parklands with spring forb meadows and oak clumps; mossy bluffs often with shrub oaks; open grassy savannahs; and woodlands sometimes mixed with Douglas-fir (*Pseudotsuga menziesii*). As well as being diverse and productive for plant growth, this landscape is attractive for human habitation and agricultural development. The consequence has been habitat loss and endangerment for Garry Oak ecosystems. There is a scientific and conservation interest in knowing more about the elements of these ecosystems, including their bird communities. Garry Oak habitat has been selected as a focus of Partners in Flight for its importance to migrating and wintering birds in the Pacific Northwest (de Groot et al. 2000). Their work includes restoration of habitat within the British Columbia range of Garry Oak (Figure1).

The purpose of this paper is to identify the bird communities of Garry Oak habitat, make comparisons of the life history traits of constituent species, and compare these communities with the literature on other habitats.

Methods

I used Detrended Correspondance Analysis (DCA, PCORD 3.0, McCune and Mefford 1997*) (Hill and Gauch 1980; Peet et al. 1988); interpretive graphing; and a quantitative similarity index (Motyka's modification of the Sorenson index, Brower et al. 1990); to determine bird communities.

I took records of bird species occurrence by ear and by sight while sampling representative ecological plots over 120 Garry Oak areas (Figure 2). This was part of an ecological reconnaissance in 1993 and 1994, cov-

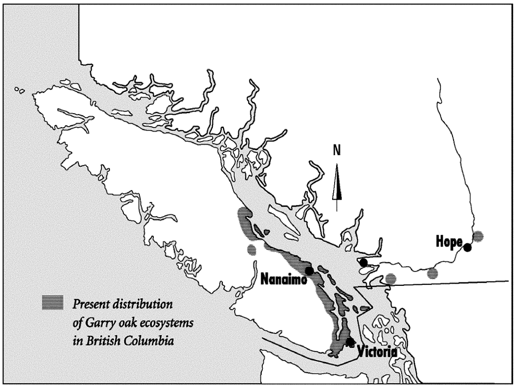

FIGURE 1. Garry Oak range in British Columbia. This map is courtesy of British Columbia Ministry of Water, Land and Air Protection, December 2003.

ering an area bounded by East Sooke, Gonzales Hill and Courtenay on Vancouver Island; and East Point, Saturna Island, and Helliwell Point, Hornby Island on the Gulf Islands (Erickson 1996). These locations are between approximately 48°N, 123°W and 49°30'N, 125°W. The Garry Oak stands sampled were primarily mature, but their canopy varied from shrub-like with exposure, to large and open on deep soils. Elevations ranged from sea level to about 550 m. Plots were approximately 200 m^2, consisted of relatively uniform vegetation and topography, and varied in size according to plant community boundaries. Species presence was recorded in an observation effort of approximately 90 minutes per plot. A total of 1243 records were taken on 286 plots (Erickson 2000b). Sampling was primarily in spring, during May and June. This time interval has migratory bird influx, spring vegetation growth, territory establishment, nesting, summer plant growth cessation and bird dispersal.

The data set had been previously checked with species accumulation curves (McCune and Mefford 1997; Erickson 2000b, unpublished data; Smith et al. 2002) to determine the adequacy of the sample. Occurrence by plot of all species with a frequency ≥5% for each year was entered into a data set; 23 species in 1993, and 29 species in 1994. This qualifying criterion reduced the number of plots to 135 in 1993 and 127 in 1994, for a total of 262 in the analysis. The DCA method uses chi-squared distances to simultaneously ordinate, in this case, bird species data against plots, and vice-versa. Axis solutions account for, and therefore represent the most variation in the data set. Bird species are separated and referenced by their scores relative to the detrended and re-scaled axes. Graphing the axis combinations provides a view of the reference coordinates in multivariate space. DCA is among the most widely used analytical methods in ecology (Peet et al. 1988). It has been applied in bird community work in oak woodland and other settings (Huff and Raley 1991; Pojar 1995; Garcia et al. 1998; Abernethy et al. 2001*; Parody et al. 2001).

In the interpretive graphing method I framed proportional circles on Axis 1 vs. 2, and Axis 1 vs. 3, on the DCA output graphs in order to outline potential bird groups. The circles represent four potential bird groups for each year's data, a number which was determined from species accumulation curve results. These

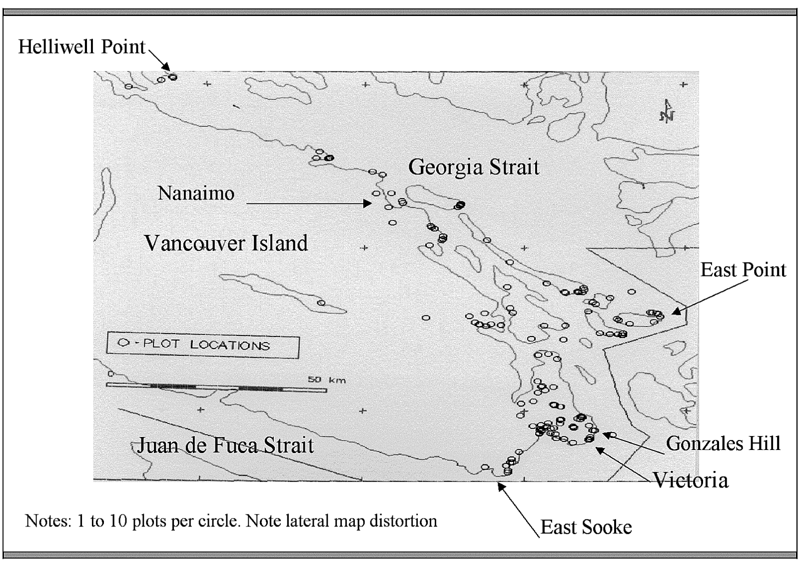

FIGURE 2. Garry Oak bird community sampling on Vancouver Island, British Columbia.

TABLE 1. Characteristic species classification.

Species classification	Symbol and similarity value	Association with a group on both axis combinations
Distinct	*d* (10)	unique to a group on both axis combinations
Companion	*c* (7)	unique to the group on one axis combination
Non differential	*n* (3)	distinct on one axis combination

results indicated that groups of approximately 35 plots could potentially cover >60% of the total species. The circles were centred on the graph coordinates from the median of the top-ranking species. Species rank was judged from the scores against each axis and the dominant axis combination (1 and 2) in the DCA result (Table 1, 2). These groups quantitatively represent the co-occurrence of species in different plots from the data, and they served as the first stage in identifying bird communities. Species were classified according to their distinctness to a group from the graphs and numeric values assigned (Table 1). Quantitative similarity index comparisons were then completed and the groups aggregated into communities based on the results.

Results

Species scores against the DCA axes are shown in Tables 2, 3 and 4. Four bird communities of Garry Oak habitat were identified by the analysis (Figures 3-6). Combinations of characteristic species, including most of the twenty top-ranking species in overall frequency, helped define the communities (Table 5). Characteristic species included American Goldfinch (*Carduelis tristis*), Spotted[1] Towhee (*Pipilo maculatus)*, Bewick's Wren (*Thryomanes bewickii*), Rufous Hummingbird (*Selasphorus rufus*) and Chestnut-backed Chickadee *(Poecile rufescens*) (community 1); House Wren (*Troglodytes aedon*), Olive-sided Flycatcher (*Contopus cooperi*), Purple Finch (*Carpodacus purpureus*), White-crowned Sparrow (*Zonotrichia leucophrys*), and Pine Siskin (*Carduelis pinus*) (community 2); Western Tanager (*Piranga ludoviciana*), Yellow-rumped Warbler (*Dendroica coronata*), American Goldfinch, Pine Siskin, Pacific-coast Flycatcher (*Empidonax difficilis*), Cassin's[1] Vireo (*Vireo cassinii*) and Chipping Sparrow (*Spizella passerine*) (community 3- 1993 only); and Northwestern Crow (*Corvus caurinus*) and European Starling (*Sturnus vulgaris*) (community 4- 1994 only).

Three groups had resulted in each of the two years, which were then reduced to the four communities. Two of these occurred across the years and two were unique to a single year. Communities were defined by the combination of their characteristic species. Similarity index values were quite low for the two across-year communities: 0.36 for community 1 and 0.43 for community 2. The two within-year communities had no similarity to each other (0 index value).

TABLE 2. Garry Oak bird species in 1993 with the highest scores against DCA axes, with median species designated*.

Species	Score
Axis 1:	
Northwestern Crow	522
Song Sparrow	499
California Quail*	388
Spotted Towhee*	388
Cedar Waxwing	388
Bewick's Wren	378
Axis 2:	
Cedar Waxwing	495
Pine Siskin	446
Bewick's Wren	400
Western Tanager*	388
Cassin's Vireo*	384
Yellow-rumped Warbler	384
California Quail	371
Song Sparrow	345
Axis 3:	
Chestnut-backed Chickadee	428
Rufous Hummingbird	336
Northern Flicker*	318
Pacific slope Flycatcher	294
Cedar Waxwing	275

TABLE 3. Garry Oak bird species in 1993 and 1994 with the highest scores against DCA axis combination 1 and 2, with median species designated*.

Year and Species	Score	Score
1993	axis 1	axis 2
California Quail	388	371
White-crowned Sparrow	183	250
Olive-sided Flycatcher*	119	230
American Goldfinch	302	342
House Wren	69	135
1994		
Brown Creeper	222	230
Rufous Hummingbird	406	275
Brown-headed Cowbird*	373	262
Northern Flicker*	258	426
Pacific-slope Flycatcher	216	162
Cassin's Vireo	254	224

Note: The former common names (Common Flicker, Rufous-sided Towhee, Common Starling, and Solitary Vireo) were used in the data and Figures for Northern Flicker, Spotted Towhee, European Starling and Cassin's Vireo.

[1] The former common names, (Common Flicker, Rufous-sided Towhee, Common Starling, and Solitary Vireo) were used in the data and Figures 1-4 for Northern Flicker, Spotted Towhee, European Starling and Cassin's Vireo.

TABLE 4. Garry Oak bird species in 1994 with the highest scores against DCA axes, with median species designated*.

Species	Score
Axis 1:	
Song Sparrow	583
Northwestern Crow*	460
European Starling*	420
Rufous Hummingbird	406
Axis 2:	
Common Flicker	426
White-crowned Sparrow	401
Song Sparrow*	294
Chipping Sparrow	283
Rufous Hummingbird	275
Axis 3:	
European starling	506
Violet-green Swallow	396
Olive-sided Flycatcher*	378
House Wren*	358
White-crowned Sparrow	327
Spotted Towhee	326

Note: The former common names (Common Flicker, Rufous-sided Towhee, Common Starling, and Solitary Vireo) were used in the data and Figures for Northern Flicker, Spotted Towhee, European Starling and Cassin's Vireo.

The overall frequency (Erickson 2000b) of these characteristic species gives an indication of the abundance of the communities. Community 1 was most frequent, with the #3-rank Spotted Towhee; the #4 Chestnut-backed Chickadee; #6 American Goldfinch; #14 Bewick's Wren and #16-rank Rufous Hummingbird. Community 2 had the #5-rank White-crowned Sparrow; #10 House Wren; #12 Pine Siskin; #13 Olive-sided Flycatcher; and the #19-rank Purple Finch. Community 3 had the #6-rank, American Goldfinch; #7 Pacific-coast Flycatcher; #11 Chipping Sparrow; #12 Pine Siskin; #18 Yellow-rumped Warbler; #21 Cassin's Vireo; and #24-rank Western Tanager. Community 4 had the #15 rank Northwestern Crow and the #26 rank European Starling.

Discussion

Sampling and analysis

Communities are differentiated here by their visual distinctness in the multivariate space defined by bird frequency and composition, and by differences defined using thresholds in quantitative index of similarity comparisons. Both measures use quantity along with composition, which ensures that the communities arising from the data are actually different from each other. Although eigenvalues can measure the overall strength of a multivariate relationship, such as the multivariate coefficient of variation for each axis in an ordination, they are not a test statistic in Detrended Correspondance Analysis.This method uses detrending and rescaling to avoid the spurious, secondary arch effect of previous techniques, but this in turn prevents the use of eigenvalues. Although the differences by year were significant for many species in previous t-test comparisons (Erickson, unpublished data), these tests are not used here, as they are not appropriate for analysis of non-experimental survey data (e.g., Hurlbert 1984).

Sampling occurred on discrete but much smaller (0.02 ha) plots in this study than in many others. How-

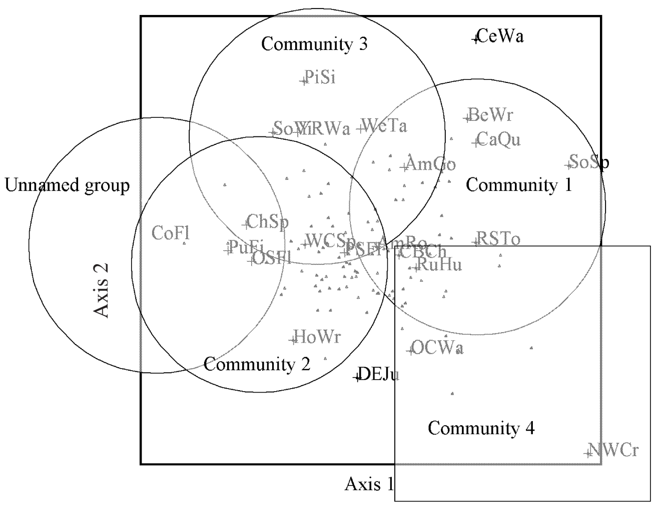

FIGURE 3. Garry Oak bird communities from DCA analysis of 1993 data, Axis 1 vs. 2. Large square represents the multivariate space formed from the data centred on the DCA axes. Circles are objectively defined groups or communities. Small square is a subjectively placed community. Bird species coordinates are marked by a cross and designated by the first letters of the common name (former names as noted in the text). Other data points are the plot coordinates.

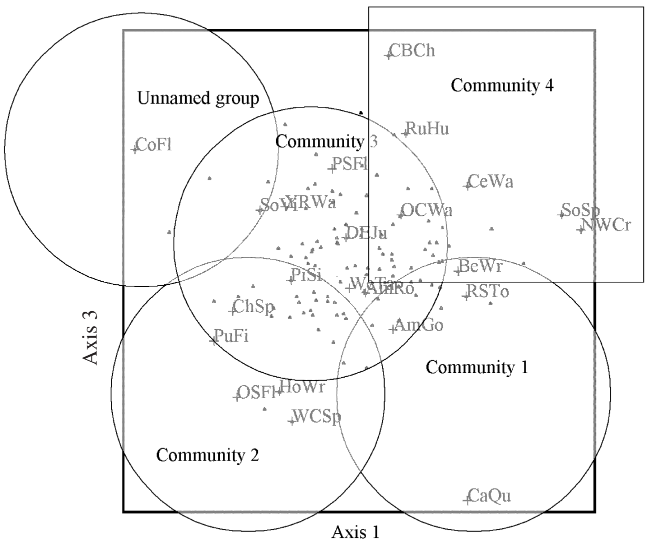

FIGURE 4. Garry Oak bird communities from DCA analysis of 1993 data, Axis 1 vs. 3. Large square represents the multivariate space formed from the data centred on the DCA axes. Circles are objectively defined groups or communities. Small square is a subjectively placed community. Bird species coordinates are marked by a cross and designated by the first letters of the common name (former names as noted in the text). Other data points are the plot coordinates.

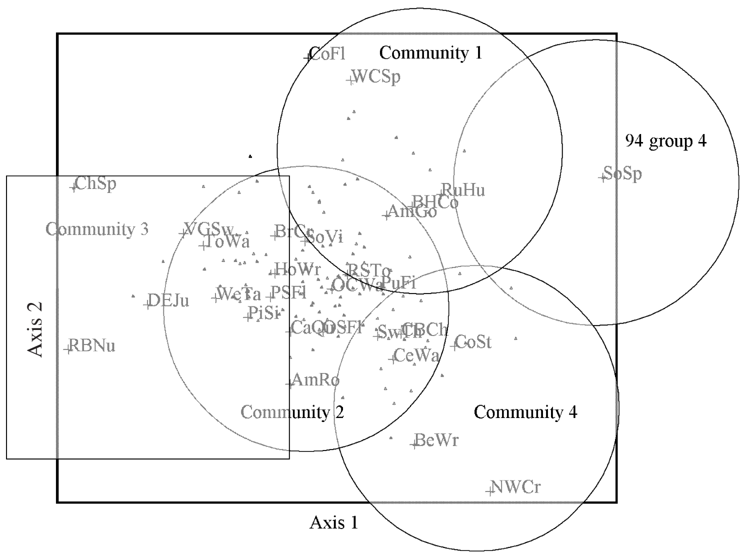

FIGURE 5. Garry Oak bird communities from DCA analysis of 1994 data, Axis 1 vs. 2. See explanation for Figure 4.

ever, the number of plots was correspondingly larger (262 plots) and records were taken over a much longer observation period (90 minutes per plot) than in many studies. Consequently, the results do not represent extreme low values in comparison to studies using other methods in oak woodlands. In my species accumulation curves, about one half the species were covered by 15 randomly selected plots, and three-quarters of the species by 45 plots (Erickson 2000a).

The average number of species detections per plot (3.7, 1993; 5.0, 1994; Erickson 2000a) is from the same order of magnitude for two count periods (3 species, 5 species per 0.28 ha plot) in Jalisco, Mexico, oak woodland; but lower than two other count peri-

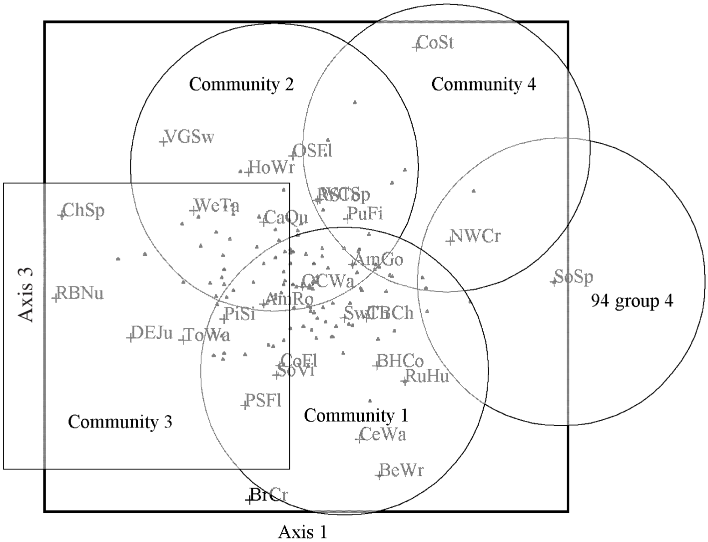

FIGURE 6. Garry Oak bird communities from DCA analysis of 1994 data, Axis 1 vs. 3. See explanation for Figure 4.

ods (10, 12 species: Corcuera and Butterfield 1999). My averages were much lower than those recorded on multiple plot, large-area studies: 21 to 25 late-spring species on five, 70 to 130 ha, stands in Oregon (Anderson 1970), and 9 to 29 breeding species from 40 ha oak census plots in Pennsylvania (Probst 1980). My total number of species detections (66) is higher than in a number of studies in oak woodland (e.g., 38 species in Dedon et al. 1984; 20 to 62 species in Leidolf et al. 2000; 43 to 51 species in Stone no date*; 50 and 58 species in each of two seasons, five forest types, Corcuera and Butterfield 1999) but is lower than in some other comparable results (e.g., 77 species in Garcia et al. 1998). My total would be increased by an additional 12 species which I recorded as "out of plot", "out of habitat", or "overhead". However, much of this difference is irrelevant, in that my interest in defining bird communities was at the plot (not area) level, and was focused on frequently occurring species which are easily detected within my plot parameters, not on less common species used to round out a full species list.

The graphical location method is an objective one, in its centering technique and the proportional allocation of multivariate space to each community. Unbiased shapes, such as squares or circles, were used to define multivariate species aggregations and overlap in composition was accepted. Other methods include subjective ones (e.g., Pojar 1995), and other objective approaches, such as the use of a "fuzzy-clustering partition coefficient" (Abernethy et al. 2001*). These methods tend to result in elliptic forms, irregular boundaries and volumes of multivariate space, and no overlap in composition. The elliptical forms assume a trend in dimensionality that does not actually occur with the DCA methodology, as it has demonstrated potential to produce evenly distibuted sample points in multivariate space (Peet et al. 1988).

Communities

Of the six groups first resulting from the DCA analysis, two from each year were similar enough (similarity index > 0.33) to combine. One group from 1994 was dropped because it had less than my conceptual threshold of three species. Two within-year communities were not differentiated by the results of the other year, but it was possible to represent them subjectively. To do so, I placed the square frame (Figures 3-6) on the graphs of the other year, and in doing so, included species and multivariate space not already covered. Through this process, Dark-eyed Junco (*Junco hyemalis*) was added to community 3 as a distinct species in 1994, although in 1993 it was limited to one of the two one-axis combinations. The two top-ranking species in frequency, Orange-crowned Warbler (*Vermivora celata*) and American Robin (*Turdus migratorius*) did not contribute to the characteristic combination of species for the communities. American Robin did qualify as a characteristic species, but was not used because it was in three out of four communities.

Consideration was given to dropping another group which occurred only in 1994, as it had only two distinct species, Northwestern Crow and European Starling. However, it was kept (as Community 4) because these two species are potentially important as ecological indicators. They may both signify a disturbance zone and represent a source of disturbance themselves, via nest predation and nest cavity competition. In addition, this community can be characterized by the absence of other species. There may be an inversely

TABLE 5. Bird communities and characteristic species of Garry Oak habitat.

Species	Group					
	93-1	94-3	93-3	94-2	93-2	94-1
Community 1						
American Goldfinch	c	c		c	c	
Spotted Towhee	d	n		c		n
Bewick's Wren	d	n				n
Rufous Hummingbird	n	d				
Chestnut-backed Chickadee	n	n		n		n
Community 2						
House Wren			d	d		
Olive-sided Flycatcher			c	d		
Purple Finch		n	c	c		n
White-crowned Sparrow		n	c	n		n
Pine Siskin		n	n	n	c	
Community 3						
Western Tanager				d	d	
Yellow-rumped Warbler					d	
Pacific-slope Flycatcher				n	c	
Cassin's Vireo					c	
Chipping Sparrow				c	c	
Dark-eyed Junco*					n	
Community 4						
European Starling						d
Northwestern Crow						d
Other species:						
Song Sparrow	n					
California Quail	d			d		
Violet-green Swallow				d		
Orange-crowned Warbler		n		c		
Townsend's Warbler				n		
Brown Creeper				n		
Cedar Waxwing		n		n		n
Swainson's Thrush		n		n		n
Common Flicker			n			
American Robin	n	n	n	c	c	

Notes: Communities are shown in the boxes. See Table 1 for species classification codes. The addition of Dark-eyed Junco to community 3 is partly subjectively derived.

proportional relationship to the presence of Northwestern Crow and European Starling across various sites. In this study, the lack of importance of another disturbance indicator, Brown-headed Cowbird (*Molothrus ater*), contrasts with the high numbers of cowbird nestlings on two Garry Oak sites west of Victoria, British Columbia (Shepard 2000). However, the present results reflect only detections of adults and fledged birds in a reconnaissance investigation.

Cross-year similarity index values were relatively low, approximately one-half of my expected threshold value of 0.66. Therefore I considered using the concept of assemblages to denote a weaker level of association. However, both the terms community (e.g., Huff and Raley 1991; Pojar 1995; Garcia et al. 1998; Abernethy et al. 2001*; Parody et al. 2001) and assemblage (e.g., Manuwal 1986; Corcuera and Butterfield 1999; Hagar and Stern 2001) receive only general use in the literature, and the term community is referred to more widely. The year differences I encountered could relate to increases in bird frequency and dominance shifts in 1994, possibly linked to yearly weather (Haila et al. 1993; Erickson 2000b).

The communities may differ in the life history traits of their characteristic species, as shown in Table 6 (Leidolf et al. 2000; Ehrlich et al. 1988), and therefore in their general habitat and guild use. Species of community 1 have mixed nest locations and most are insectivorous when on breedng territory. Those of community 2 have an equal dominance of granivores with insectivores. Most species of community 3 forage in shrubs and trees. Community 4 species are tree-nest-

TABLE 6. Life history traits for characteristic species of Garry Oak bird communities.

Community and species	Nest Location	Foraging Layer	Foraging Method	Food Type
Community 1:				
American Goldfinch	SH	HB/ SH/ TR	FG	GV
Spotted Towhee	GR/ SH	GR	GG	IN/ OM
Bewick's Wren	TR	GR	GG	IN
Rufous Hummingbird	VN/ TR	HB	HG	NE
Chestnut-backed Chickadee	SN	SH/ TR	BG	IN
American Robin	SH/ TR	GR/ SH/ TR	GG/FG	IN/ FR
Community 2:				
House Wren	TR	GR	GG	IN
Olive-sided Flycatcher	TR	AIR	HA	IN
Purple Finch	TR	GR	GG	GV
American Robin	SH/ TR	GR/ SH/ TR	GG/ FG	IN/ FR
White-crowned Sparrow	SH	GR	GG	GV
Pine Siskin	TR	HB/ SH/ TR	FG	GV
Community 3:				
Western Tanager	TR	SH/ TR	FG	IN
Yellow-rumped Warbler	TR	SH/ TR	FG	IN
American Goldfinch	SH	HB/ SH/ TR	FG	GV
American Robin	SH/ TR	GR/ SH/ TR	GG/FG	IN/ FR
Pine Siskin	TR	HB/ SH/ TR	FG	GV
Pacific-slope Flycatcher	TR	AIR	HA	IN
Cassin's Vireo	TR	SH/ TR	FG	IN
Chipping Sparrow	SH/ TR	GR	GG	IN/ GV
Dark-eyed Junco	GR	GR	GG	GV
Community 4:				
Northwestern Crow	TR	GR	GG	OM
European Starling	TR	GR	GG	IN

Note: Nest location: TR-tree, VN-vine; GR-ground, SH-shrub, SN-snag. Foraging Layer: AIR-air, GR-ground, HB-herb, SH-shrub, TR-tree. Foraging Method: BG-bark glean, FG-foliage glean, GG-ground glean, HA-hawk, HG-hover and glean. Food Type: FR-frugivore; GV-granivore; IN-insectivore; NE-nectarivore, OM-omnivore.

ing ground gleaners. Shared traits are as follows: tree nesting insectivores (community 2,3) and ground gleaning (1,2,4). The comparison may suggest general habitat and guild relationships for the communities. This could include open savanna settings (community 2,4) and shrubby woodlands or shrub oak (community 1,3). More work is needed on habitat relationships though.

Comparison with other studies

In this study, bird communities have been delineated within the Garry Oak habitat at a detailed level by aggregations of the bird species themselves. This approach is not typical in the literature. There are indications of different bird communities in the discussion of Hagar and Stern (2001) for Garry Oak woodlands, including Chipping Sparrow as a species of semi-open woodland and Orange-crowned Warbler as shrub-associated. Dedon et al. (1984) employed habitat suitability class lists, possibly comparable to more detailed communities, in California Black Oak (*Quercus kelloggii*) habitat. One shrub community was identified to subdivide Gambel Oak (*Quercus gambellii*) woodlands (Stone no date*) in Colorado. Artman et al. (2001) found in Ohio that differences in bird communities within mixed oak forests could be related to three moisture index classes. Pojar (1995) described separate bird communities within Trembling Aspen forests of north-central British Columbia.

In most oak woodland bird studies, bird communities have been identified at a more general level. Broad habitat groupings have formed bird communities, guilds have been separated by shared traits, or communities have been grouped by successional stages (e.g., Anderson 1970; Smith 1977; Probst 1980; Davis et al. 2000; Hagar and Stern 2001). Both Leidolf et al (2000) and Stone (no date*) described bird communities associated with four different Gambel Oak habitats (i.e., oak woodland, submontane shrub, Ponderosa Pine (*Pinus ponderosa*)/oak woodland, and mixed conifer/oak woodland), and locations. Garcia et al. (1998) and Corcuera and Butterfield (1999) referred to separate bird communities in oak woodlands, mixed oaks (*Quercus rugosa, Q. candicans, Q. obtusata, Q. laurina*) and other groupings for north-central Michoacan, Mexico.

Some comparisons and comments can be made about the composition of communities from the present study in relation to these others. Shepard (2000) outlined the importance of House Wren (found in community 2) for two Garry Oak sites west of Victoria, British Columbia. However, those sites had steady numbers of Red-breasted Nuthatch (*Sitta canadensis*) and Brown Creeper (*Certhia americana*), species which were unimportant in the present study. Most of the frequent birds from my study were present in Black Oak habitat in northern California, but no more than one or two species were listed by habitat suitability class (Dedon et al. 1984). Five of the seven species of community 3 were resident or breeding species in the ponderosa pine/Gambel Oak forest in north-central New Mexico (Leidolf et al 2000). The two remaining species are not found in the range of Gambel Oak. However, the shrub subdivision in Gambel Oak bird communities (Stone no date*) is not similar to the four communities except for the presence of Spotted Towhee. A community from Trembling Aspen forests in north-central British Columbia had similarities (4/7 species) to community 3 (Pojar 1995). Although this was labelled a group of conifer-related species, three of four species were associated with Gambel Oak and Trembling Aspen in southwestern Colorado (Stone no date*). In addition, Shepard (2000) mentioned high densities of Pacific-slope Flycatcher, also a species of community 3; and the importance of Chesnut-backed Chickadee (found in community 1), for two Garry Oak sites in British Columbia. These species have similarly been thought of as conifer (Douglas-fir)-related (Huff and Raley 1991). Neither the other two Trembling Aspen bird communities (Pojar 1995), nor the ones described for Douglas-fir habitat (Shepard 2000; Huff and Raley 1991) had any substantial similarity to the four communities in the present study.

Summary

Testing of wildlife habitat relationship models based on broad habitats (e.g., oak woodland, old-growth Douglas-fir forest) has given results which questioned their basic utility (e.g., Dedon et al. 1984; Laymon 1989). This suggests that other methods could be examined. An alternative approach, which empirically defines spatial and temporal bird aggregations as bird communities, is presented here, and may warrant further investigation.

The four communities identified in this work could serve as benchmarks in Garry Oak ecosystem studies. Like any classification, they should be tested with further field work and analysis, particularly for differentiation by habitat features. For example, Erickson and Campbell (2001) related correlations involving moisture regime, oak diameters, tree form complexity, total wildlife habitat features, and, for one year, average number of bird species per plot. Monitoring is recommended as a first step in maintaining characteristic Garry Oak bird communities, a focus which should parallel growing concern for this endangered habitat and contribute to increasing conservation efforts.

Acknowledgments

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Documents Cited (marked * in text)

Abernethy, V. J., D. I. McCracken, A. Adam, I. Downie, G. N. Foster, R. W. Furness, K. J. Murphy, I. Ribera, A. Waterhouse, and **W. L. Wilson** 2001. Functional analysis of plant-invertebrate-bird biodiversity on Scottish agricultural land. Website posting (Accessed 13 January 2005): http://www.gla.ac.uk/ibls/DEEB/kjm/divpap.html.

Erickson, W. R. 1993. Garry oak ecosystems at risk (brochure). Wildlife Branch, British Columbia Ministry of Environment, Lands and Parks, Victoria. Website posting (Accessed 13 January, 2005): http://wlapwww.gov.bc.ca/wld/list.htm.

McCune, B., and **M. J. Mefford.** 1997. PCORD: Multivariate analysis of ecological data, version 3.0. MjM Software Design. Gleneden Beach, Oregon.

Stone, E. no date. Avian communities of Gambel oak habitats in southwestern Colorado. Website posting (Accessed 10 Februrary 2003): www.colorado.edu/epob/epob4630estone/ES/ResearchStuff/Oak/Oak.html

Literature Cited

Anderson, S. H. 1970. The avifaunal composition of Oregeon white oak stands. Condor 72: 417-423.

Artman, V. L., E. K. Sutherland, and **J. F. Downhower.** 2001. Prescribed burning to restore mixed-oak communities in southern Ohio: Effects on breeding-bird populations. Conservation Biology 15: 1423-1434.

Brower, J. E., J. H. Zar, and **C. N. von Ende.** 1990. Field and laboratory methods for general ecology. 3rd Edition. Wm. C. Brown Publishers, Dubuque, Iowa.

Corcuera, P. M. D. R., and **J. E. L. Butterfield.** 1999. Bird communities of dry forests and oak woodland of western Mexico. Ibis 141: 240-255.

Davis, M. A., D. W. Peterson, P. B. Reich, M. Crozier, T. Query, E. Mitchell, J. Huntington, and **P. Bazakas.** 2000. Restoring savanna using fire: Impact on breeding bird community. Restoration Ecology 8: 30-40.

Dedon, M. F., S. A. Laymon, and **R. H. Barrett.** 1984. Evaluating models of wildlife-habitat relationships of birds in black oak and mixed conifer habitats. Page 115-119 *in* Wildlife 2000: Modelling habitat relationships of terrestrial vertebrates. *Edited by* J. Verner, M. L. Morrison, and C. J. Ralph. University of Wisconsin Press, Madison.

de Groot, K., P. Boulay, C. MacDonald, G. Fitzpatrick, K. Floe, T. Ennis, and **P. Dunn.** 2000. So a mighty oak can grow: A bird's eye view of the Oak Woodlands Restoration project. Bird Conservation 14: 6-7. Website posting (Accessed 25 November 2004): http://www.partnersinflight.org/pubs/birdcons/14pgs6-7.pdf.

Ehrlich, P. R., D. S. Dobkin, and **D. Wheaye.** 1988. The birder's handbook: A field guide to the natural history of North American birds. Simon and Schuster, Toronto.

Erickson, W. R. 1996. Classification and interpretation of Garry oak (*Quercus garryana*) plant communities and ecosystems in southwestern British Columbia. M.Sc. thesis. University of Victoria, Victoria, British Columbia.

Erickson, W. R. 2000a. Garry oak communities in Canada: Classification, characterization and conservation. International Oaks 10: 40–54.

Erickson, W. R. 2000b. Birds of the Garry oak habitat in British Columbia. British Columbia Birds 10: 5-12.

Erickson, W. R., and **D. C. Campbell.** 2001. Aspects of the form, ecological function and aesthetics of Garry oak and its environment in southwestern British Columbia, Canada. International Oaks 12: 39-47.

Garcia, S., D. M. Finch, and **L. D. Chavez.** 1998. Patterns of forest use and endemism in resident bird communities of north-central Michoacan, Mexico. Forest Ecology and Management 110: 151-171.

Hagar, J. C., and **M. A. Stern.** 2001. Avifauna in oak woodlands of the Willamette Valley, Oregon. Northwest Naturalist 82: 12-25.

Haila Y., I. Hanski, and **S. Ravio.** 1993. Turnover of breeding birds in small forest fragments: The sampling colonization hypothesis corroborated. Ecology 74: 714-725.

Hill, M. O., and **H. G. Gauch.** 1980. Detrended correspondance analysis: an improved ordination technique. Vegetatio 42: 47-58.

Huff, M. H., and **C. M. Raley.** 1991. Regional patterns of diurnal breeding bird communities in Oregon and Washington. Pages 117-121 *in* Wildlife and vegetation of unmanaged Douglas-fir forests. *Technically coordinated by* L. F. Ruggiero, K. B. Aubry, A. B. Carey and M. H. Huff. United States Department of Agriculture Forest Service General Technical Report PNW-GTR-285. Portland, Oregon.

Hurlbert, S. H. 1984. Pseudo-replication and the design of ecological field experiments. Ecological Monographs 54: 187-211.

Laymon, S. A. 1989. A test of the California Wildlife-Habitat Relationship system for breeding birds in Valley-Foothill riparian habitat. Pages 307-313 *in* Proceedings of the California riparian systems conference. United States Department of Agriculture Forest Service General Technical Report PSW-119. Davis, California.

Leidolf, A., M. L. Wolfe, and **R. L Pendleton.** 2000. Bird communities of Gambel oak: A descriptive analysis. United States Department of Agriculture Forest Service General Technical Report RMRS-GTR-48. Fort Collins, Colorado.

Manuwal, D. A. 1986. Characteristics of bird assemblages along linear riparian zones in western Montana. Murrelet 67: 10-18.

Parody, J. M., F. J. Cuthbert, and **E. H. Decker.** 2001. The effect of 50 years of landscape change on species richness and community composition. Global Ecology and Biogeography 10: 305-313.

Peet, R. K., R. G. Knox, J. S. Case, and **R. B. Allen.** 1988. Putting things in order: The advantage of Detrended Correspondance Analysis. American Naturalist 131: 924-934.

Pojar, R. A. 1995. Breeding bird communities in aspen forests of the Sub-Boreal Spruce (dk Subzone) in the Prince Rupert Forest Region. British Columbia Ministry of Forests, Land Management Handbook 33. Victoria.

Probst, J. R. 1980. Oak forest bird communities. Pages 80-88 *in* Management of North Central and Northeastern forests for nongame birds. Workshop Proceedings, July 23-25, *Compiled by* R. M., DeGraaf and K. E. Evans. United States Department of Agriculture Forest Service General Technical Report NC-51. Central Forest Experimental Station. Minneapolis Minnesota.

Shepard, M. G. 2000. Breeding bird censuses in Garry oak forests, with notes on habitat use, metapopulations, and consequences of forest fragmentation. Pages 277-278 *in* Proceedings of a conference on the biology and management of species and habitats at risk, Feb. 15-19, Kamloops, British Columbia. *Edited by* L. M. Darling. British Columbia Ministry of Environment, Lands and Parks, Victoria.

Smith, K. G. 1977. Distribution of summer birds along a forest moisture gradient in an Ozark watershed. Ecology 58: 810-819.

Smith, W., A. Solow, and **S. Chu.** 2002. An index of the contribution of spatial community structure to the species-accumulation curve. Ecology 81: 3233-3236.

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