CHAPTER 12 BIRD COMMUNITIES IN RELATION TO WATERSHED DEVELOPMENT

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INTRODUCTION

Wetlands are recognized because of the disproportionate habitat value they provide for birds (Chapter 6 in this volume). Wetlands, however, are under increasing threat from watershed development in urbanizing areas. Landscape conversion from forests to residential housing and other developments remove or alter habitat immediately adjacent to wetlands and fragment habitat that remains. Moreover, wetlands themselves may be altered in their hydrology and water quality, directly influencing bird populations or indirectly affecting them by altering wetland vegetation. Collectively, these alterations may change breeding, nesting or feeding habitat and competitive interactions among and between species resulting in population shifts.

Striking bird population changes in terrestrial habitat within urbanizing landscapes have been documented. Blair (1996) in his review of researchers' findings of bird distributions along terrestrial gradients of urbanization, summarized that: (1) species composition changes in an area as it becomes urbanized; (2) almost always, the number of species decreases with increasing urbanization; and (3) all agree that bird density or abundance increases with urbanization. More specifically, urbanization is generally found to be correlated with increasing biomass and density and favoring dominance by a few urban ground gleaners where forest insectivores, canopy foliage gleaners or bark drillers used to forage (Beissinger and Osborne 1982).

Few studies, however, have investigated the impacts of watershed development on birds of wetlands. Birds of wetlands may directly be threatened by impacts to marshes, swamps and bogs and secondarily by habitat changes attributable to urbanization within the landscape. Foremost, wetland impacts include urban stormwater runoff that flood nest sites and disperses pollutants that may bio-acumulate in birds through aquatic food chains. Moreover, runoff may alter the areal extent of open water, existing hydrology, vegetation classes and other wetland characteristics influencing cover, nesting habitat and food distribution. Concomitantly, urbanization may influence wetland buffers and adjacent lands, which may also be reflected in changing bird distributions and abundances.

In this paper we describe the changing bird communities in wetlands across a gradient of increasing watershed development and within wetlands that have been altered during the duration of this study. We hypothesize that bird species diversity and abundance changes with increasing watershed development. Although total bird diversity may remain the same in wetlands, we predict that abundances of native species, especially urban-intolerant species, should decline and urban adapters and exploiters increase. Specifically, the proportion of species with low tolerances to habitat changes should be lower in wetlands affected by development than unaffected wetlands.

In part, these predicted changes are based on the fact that the distribution and abundance of birds are widely accepted as functions of vegetation structure and diversity which, in itself, is altered by development in watersheds. Therefore, we

hypothesize that bird species richness, diversity, and relative abundance reflect the structural diversity of vegetation at wetlands, with those wetlands with greatest vegetation changes exhibiting the greatest avifaunal changes.

METHODS

Bird survey methods are described in the companion paper on bird distributions in the wetlands of the Puget Sound Basin (Chapter 6). In this chapter we compare the pre-development and post-development alpha diversities of birds for life history characteristics covering adaptability and residency. We also evaluate bird density as measured by the average number of detections per visit to a wetland. Initially, to examine adaptability, we characterized species as invasive and non-invasive by identifying invasive birds as alien species spreading naturally (without the direct assistance of people) in natural or seminatural wetlands, to produce a significant change in terms of composition, structure or ecosystem process, which was a definition applied to invasive

vegetation by Cronk and Fuller (1995). Subsequently we identified species as 1) urban exploiters, 2) urban avoiders and 3) suburban adaptable using the criteria specified by Blair (1996) and based on species sensitivity to human-induced changes in wetlands and watersheds. We also characterize birds by whether they were common residents, rare residents or seasonal migrants according to Hunn (1982).

Wetland vegetation, hydrology and surrounding land use were measured as described in Sections 1 and 2 of this report. In addition, we characterize wetlands according to watershed condition and their level of disturbance, or treatment, during the course of our study. These experimental categories included wetlands in rural areas which did not change during our study (Rural Controls), wetlands which began the study in an urbanized area (Urban Controls) and wetlands which had 10% or more of their watershed develop, regardless of previous condition, during the study period (Treatments). We also examined the availability of suitable habitats for birds adjacent to wetlands, including forests, with and without single family housing, open water and shorelines. Undeveloped meadow and shrub-land were also evaluated as additions to suitable habitats whereas unsuitable habitat always included developed or cleared land and agricultural lands.

Statistical analysis of correlations and hypothesis testing utilized parametric statistics when assumptions of normality were met and non-parametric statistics when assumptions were violated. We chose $p \leq 0.05$ and $p \leq 0.10$ as significant and weakly significant, respectively, for reporting results. Nevertheless, significance should be interpreted cautiously because of the variability in sampling populations of species and the low number of wetlands undergoing impacts that could be observed in changing bird sightings during the period of our study.

RESULTS

Total alpha diversity decreased significantly among all wetlands between 1989 and 1995 (Friedman test (F), $\chi 2 = 18.3$, $p \leq 0.0001$). Total alpha diversity also decreased among all wetlands when analyzed by experimental category. Both wetlands in developed (urban controls) and undeveloped (rural controls) watersheds showed a significant decline in total diversity (F, $\chi 2 = 5.6$, $p = 0.06$ and F, $\chi 2 \geq 4.8$, $p = 0.09$, respectively), as

did wetlands in watersheds with increased development (treatments) during the study (F, $\chi 2$ = 9.0, p = 0.01).

Total diversity in a single wetland ranged from 16 to 57 species over the study period and averaged 38 among all wetlands in 1989, the year of highest recorded richness. During that same year, we observed an average of 37 bird species in both the urban control and rural control wetlands and an average of 38 in the treatment wetlands. By the last year of our surveys, 1995, total diversity within wetlands with undeveloped uplands averaged 31. In the treatment wetlands and in the urban control wetlands, an average of 28 species were detected.

Average alpha diversity, similar to total diversity decreased significantly for all wetlands (F, $\chi 2$ = 13, p = 0.0015). However, average alpha diversity only decreased significantly among the wetlands with watersheds affected by urbanization whether past (urban controls) (F, $\chi 2$ = 7.0, p = 0.03) or during the study period (treatments) (F, $\chi 2$ = 5.5, p = 0.06). Average diversity for all wetlands in undeveloped watersheds at the end of our study (controls) remained unchanged (F, $\chi 2$ = 3.1, p = 0.2) (Figure 12-1).

The average number of birds detected at all 19 wetlands slightly increased, from 1989 to 1995 (F, $\chi 2 \geq 4.8$, p = 0.09), but simultaneously, we found average detections unchanged among all experimental categories, the urban controls (F, $\chi 2 \geq 2.0$, p = 0.37), the treatment wetlands (F, $\chi 2 \geq .33$, p = 0.84) and among the rural control wetlands (F, $\chi 2 \geq 3.2$, p = 0.2) (Figure 12-2). A complete list of detection rates for all species is available in Appendix Table 12-1.

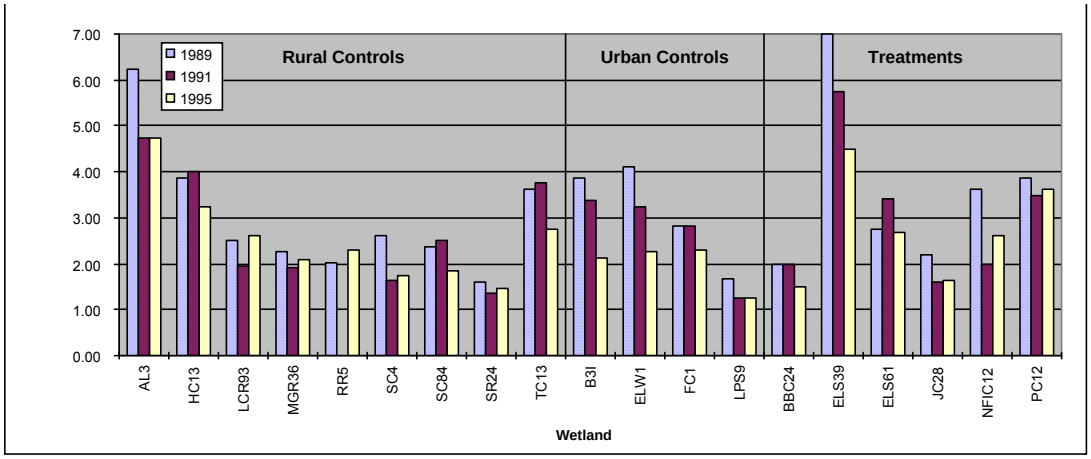

Figure 12-1. Average wetland alpha diversity over the study period by experimental category.

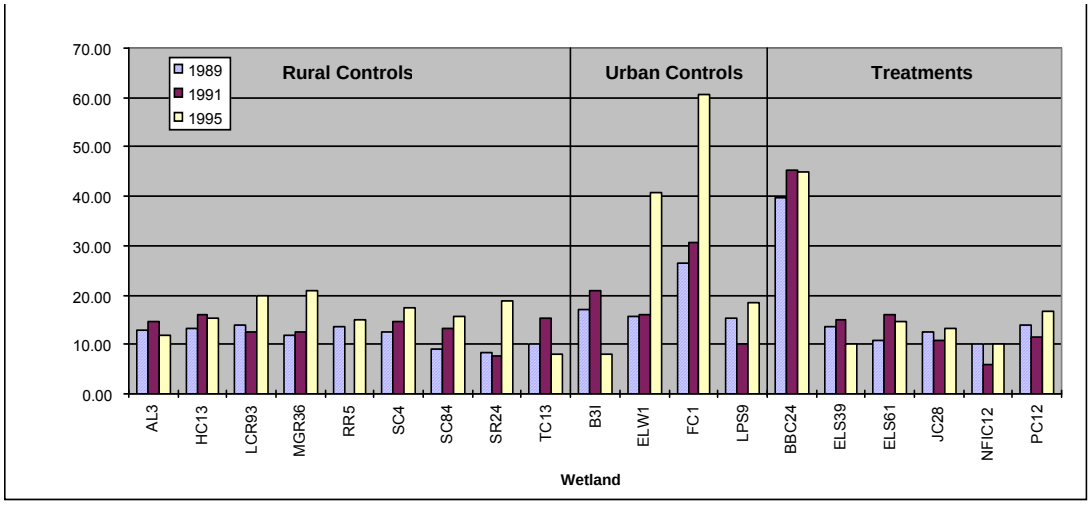

Figure 12-2. Average avian detection rate over the study period by wetland and experimental category.

We found that bird richness decreased and abundance remained the same in wetlands with developed or developing watersheds (urban control or treatment) but found richness unchanged in wetlands with rural, relatively pristine watersheds (rural controls).

Interestingly, although alpha bird diversity was statistically related to development in the watershed, we did not find diversity to be related to urbanization within 1000 meters of the wetlands. Although, increasing percentages of forest land within 1000 meters of the wetland did not add to diversity, the presence of forest land did affect the structure of bird communities from about 500 meters to 1000 meters (the maximum distance we studied). We found that species richness of birds known to avoid human development (avoiders) increased over the study period primarily in wetlands with high percentages of adjacent forest land within 500 meters (Mann-Whitney (MN), $p < 0.09$) whereas they decreased among the already urban wetlands and in those where land use changes decreased watershed habitat (Figure 12-3).

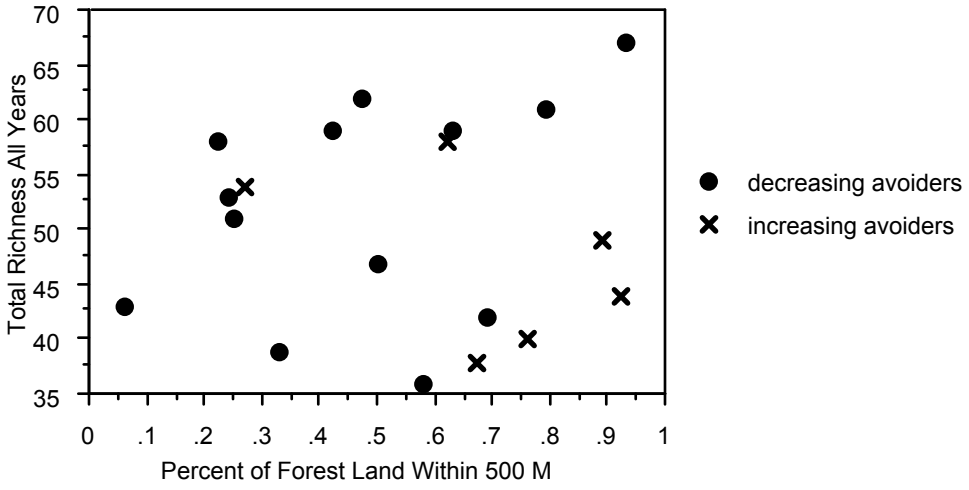

Figure 12-3. Species richness and whether the number of avoiders in the population increased or decreased related to the presence of forest land.

Detections of migrants declined during the study among all wetlands combined (F, $\chi 2$ = 31.6 $p \leq 0.0001$) as did rare residents (F, $\chi 2$ = 6.4, p = 0.04) while detections of residents remained the same. Migrants also declined within all experimental categories (F, $\chi 2 \geq 7.1$ $p \leq 0.02$) but detections of rare residents did not show any significant change within the experimental groups. Detections of resident species did not change among the rural control and treatment wetlands but declined in the urban control wetlands (F, $\chi 2$ = 5.1, p = 0.07).

Across all wetlands, the number of detections of species that avoid development and adaptive species declined during the study (F, $\chi 2 \geq 10.1$, $p \geq 0.007$) while densities of invasive or exploitive species stayed the same. Detections of avoiding species declined among the already urban and treatment wetlands but not the rural control wetlands (F, $\chi 2 \geq 9.1$, $p \leq 0.01$). The greatest declines of adaptive species occurred in treatment wetlands (F, $\chi 2 \geq 7.5$, $p \leq 0.02$). While exploitive species detections were not significantly different between years in wetlands overall, among the rural control wetlands in non-urbanized areas, densities of exploitive species increased significantly (F, $\chi 2$ = 5.6, p = 0.06) from 1989 to 1995. Density changes included increases in such invasive species as American crow, European starling and house sparrow.

Three wetlands, ELS39, ELS61 and NFIC12 exhibited dramatic vegetation changes during our study and also showed significant changes in bird species. At ELS39 species richness decreased from 28 to 23 and then to 18, from 1989, 1991 and 1995, respectively. Species disappearing included marsh wren, pine siskin and red-breasted nuthatch. Species increasing included, among others, urban habitat exploiters and adapters such as American crow, mallard, California quail, and rufous-sided towhee. At ELS61 species richness decreased from 44 to 32 species between 1989 and 1995 and at NFIC12 species decreased from 29 to 21. Within both wetlands sightings of American robin and black-capped chickadees increased.

DISCUSSION

Although our study intensively covers the wetlands of the lower Puget Sound region and represents a first comprehensive account of wetland bird diversity, we consider our work to date as a rough initial attempt to assess bird densities and population trends over the study period. Blair (1996) found that urbanization affects bird diversity in two distinct ways: moderate levels of development may both increase overall species diversity and decrease native bird diversity whereas increasingly severe development lowers total and native species diversity. Although moderate development increases diversity this increase seems attributable to the addition of widely distributed species at the expense of native species. Our findings agree with Blair in that, in general, we found average alpha diversity decreasing in wetlands in watersheds affected by urbanization but also in some wetlands not affected by urbanization. In addition, we found that abundance of birds (detection rate) increased among all the wetlands, yet remained unchanged in all experimental categories in undeveloped areas but decreased in those wetlands where development occurred or pre-existed. Moreover, detection of many native species that avoid urbanization decreased in all but rural wetlands in which development did not occur.

Decreasing diversity and increasing numbers in response to isolation were observed by Brown and Dinsmore (1986) who found that wetland size and isolation account for 75% of the variation in species richness observed within prairie marshes. They also found that species richness was often greater in wetland complexes than in simple larger isolated marshes. Although, we found that the presence of forest within 0 to 500 meters was not correlated to avian richness or overall abundance, forests within the entire watershed did suggesting that wooded areas near but not adjacent to wetlands are important. We also found that wetlands with significant forest land remaining within 500 to 1000 meters, did account for increasing numbers of species that avoid urbanization, even though adaptable and exploitive species generally declined during the same period.

For the most part we found the wetland avifauna to be an extension of the upland avifauna. As expected, in wetlands of undisturbed landscapes (such as SR24 and RR5) species diversity is dominated by residents and migrants whereas wetlands in more urban areas (such as B3I and FC1) bird diversity is characterized by increasing numbers of non-native species including American crow, European starlings, house sparrows and some brown-headed cowbirds. We have seen European starlings displace cavity nesters including swallows and chickadees. Moreover, we have seen American Crows raid passerine nests. The shift of bird communities from predominantly native species in undisturbed areas to invasive species in highly developed areas is well documented in terrestrial environments (Blair 1996) and we saw similar shifts among some, but not all, wetlands within this study. Nevertheless, observations must be cautiously interpreted as recent literature suggests that determining bird diversity and abundance is extremely difficult (James et al. 1996, Thomas and Martin 1996), and furthermore, may be driven by immigration from few large regional source sites that produce surpluses (Brawn and Robinson 1996) rather than by more local conditions.

Based on these results, we predict that the distribution and abundance of species will change more dramatically as urbanization continues and becomes more severe. Specifically, we would expect decreasing diversity and abundances of migrants and residents and increasing nest predators including urban exploiters like the American crow and European starling as well as and nest parasites such as brown-headed cowbird. Other factors contributing to declines in birds that avoid urbanization are the density of predators like domestic cats and introduced rodents such as Norway rats and brown rats. We especially expect significant reductions in ground nesting species as increasing numbers of predators are introduced with human development.

Many wetlands in our study still exhibit a wide variety of vegetation structure and microhabitats that enable a rich diversity of birds to be found. However, with increasing urbanization and habitat fragmentation that separates wetlands from larger upland habitats and wetlands from each other, diversity of native species may be expected to decrease (as for example in urban areas, Milligan 1985). To avoid these effects, we recommend that forest land with complex structure be retained to the greatest extent possible in areas adjacent to wetlands. Dense stands of herbs and shrubs should also be retained to provide cover to birds and restrict the movement of avian predators. Access via roads, trails and footpaths that enable disturbance by humans and use by pets should be limited and edge habitat minimized as edge-related problems of thermo-regulation, predation and nest-parasitism increases along edges.

Our data supports the increasingly accepted view that total species richness is not an adequate measure of community condition under threat because the increasing

diversity, attributable to urban exploiters and urban adaptable species, is in fact an indication of wetland functional deterioration. To maintain regional biodiversity, it is critical to differentiate between native species with distinct habitat preferences and invasive species and adaptable species associated with urbanization, and to maintain habitat for native, specialized species rather than the increasingly common adptable birds. Finally, wetlands must be viewed as dynamic ecosystems which must be managed for diversity over the entire landscape and not just as individual isolated habitats.

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Appendix Table 12-1. Abundance and detection rates of species over all wetlands.

	Abundance				Detection Rate			
Species	1989	1991	1995	All Years	1989	1991	1995	All Years
American Coot	4	22	9	35	0.014	0.087	0.034	0.045
American Crow	117	160	287	564	0.418	0.635	1.087	0.727
American Goldfinch	99	76	67	242	0.354	0.302	0.254	0.312
American Robin	294	239	322	855	1.050	0.948	1.220	1.102
Anna's Hummingbird	2		1	3	0.007	0.000	0.004	0.004
Bald Eagle		1	3	4	0.000	0.004	0.011	0.005
Barn Swallow	19	18	64	101	0.068	0.071	0.242	0.130
Black-capped Chickadee	213	194	245	652	0.761	0.770	0.928	0.840
Belted Kingfisher	7	4	10	21	0.025	0.016	0.038	0.027
Bewick's Wren	49	42	68	159	0.175	0.167	0.258	0.205
Brown-headed Cow Bird	23	16	39	78	0.082	0.063	0.148	0.101
Black Headed Grosbeak	57	38	64	159	0.204	0.151	0.242	0.205
Brewer's Blackbird	10	15	127	152	0.036	0.060	0.481	0.196
Brown Creeper	9	8	5	22	0.032	0.032	0.019	0.028
Black-throated Gray Warbler	25	13	44	82	0.089	0.052	0.167	0.106
Band-tailed Pigeon	4	2	4	10	0.014	0.008	0.015	0.013
Bushtit	126	88	141	355	0.450	0.349	0.534	0.457
Blue-winged Teal			2	2	0.000	0.000	0.008	0.003
Canada Goose	6	4	259	269	0.021	0.016	0.981	0.347
California Quail	1		3	4	0.004	0.000	0.011	0.005
Caspian Tern			13	13	0.000	0.000	0.049	0.017
Chestnut-backed Chickadee	63	77	74	214	0.225	0.306	0.280	0.276
Cedar Waxwing	111	74	110	295	0.396	0.294	0.417	0.380
Chipping Sparrow		1	2	3	0.000	0.004	0.008	0.004
Cliff Swallow	18	9	4	31	0.064	0.036	0.015	0.040
Cooper's Hawk	2		7	9	0.007	0.000	0.027	0.012
Common Raven			5	5	0.000	0.000	0.019	0.006
Common Yellow-throat	95	63	69	227	0.339	0.250	0.261	0.293
Dark-eyed Junco	40	17	32	89	0.143	0.067	0.121	0.115
Downy Woodpecker	16	14	28	58	0.057	0.056	0.106	0.075
European Starling	122	180	445	747	0.436	0.714	1.686	0.963
Evening Grosbeak	23	1	23	47	0.082	0.004	0.087	0.061
Fox Sparrow	1		5	6	0.004	0.000	0.019	0.008
Gadwall	5	4	4	13	0.018	0.016	0.015	0.017
Great Blue Heron	18	9	25	52	0.064	0.036	0.095	0.067
Golden-crowned kinglet	96	73	19	188	0.343	0.290	0.072	0.242
Green Heron	12	1	1	14	0.043	0.004	0.004	0.018
Glaucous Winged Gull	3	1	2	6	0.011	0.004	0.008	0.008
Hammond's Flycatcher	9	10	2	21	0.032	0.040	0.008	0.027
Hairy Woodpecker	40	17	13	70	0.143	0.067	0.049	0.090
Hermit Thrush	85	11	8	104	0.304	0.044	0.030	0.134
House Finch	23	8	16	47	0.082	0.032	0.061	0.061
Hooded Merganser	14		9	23	0.050	0.000	0.034	0.030
House Sparrow	9	5	2	16	0.032	0.020	0.008	0.021
Hutton's Vireo	21	1	3	25	0.075	0.004	0.011	0.032
Killdeer	6		4	10	0.021	0.000	0.015	0.013
Mallard	44	50	223	317	0.157	0.198	0.845	0.409
Marsh Wren	56	23	24	103	0.200	0.091	0.091	0.133
MacGillivary's Warbler	2		6	8	0.007	0.000	0.023	0.010
Northern Flicker	10	12	24	46	0.036	0.048	0.091	0.059
Northern Oriole	4		2	6	0.014	0.000	0.008	0.008

Appendix Table 12-1 continued. Abundance and detection rates of species over all wetlands.

	Abundance				Detection Rate			
Species	1989	1991	1995	All Years	1989	1991	1995	All Years
Northern Pigmy Owl		1	2	3	0.000	0.004	0.008	0.004
Orange-crowned Warbler	38	23	12	73	0.136	0.091	0.045	0.094
Olive-sided Flycatcher	5	8	2	15	0.018	0.032	0.008	0.019
Pied-billed Grebe	8	2	20	30	0.029	0.008	0.076	0.039
Pine Siskin	14		18	32	0.050	0.000	0.068	0.041
Pileated Woodpecker	13		4	17	0.046	0.000	0.015	0.022
Pacific-slope Flycatcher	127	147	145	419	0.454	0.583	0.549	0.540
Purple Finch	24	22	40	86	0.086	0.087	0.152	0.111
Red-breasted Nuthatch	15	29	42	86	0.054	0.115	0.159	0.111
Red-breasted Sapsucker	4		4	8	0.014	0.000	0.015	0.010
Red Crossbill	9	42	4	55	0.032	0.167	0.015	0.071
Red-eyed Vireo	2		9	11	0.007	0.000	0.034	0.014
Red-eyed Vireo	2	1	5	8	0.007	0.004	0.019	0.010
Rock Dove	5	4		9	0.018	0.016	0.000	0.012
Rufous-sided Towee	101	98	143	342	0.361	0.389	0.542	0.441
Rufous Hummingbird	6	5	4	15	0.021	0.020	0.015	0.019
Ruffed Grouse	1	2	2	5	0.004	0.008	0.008	0.006
Ruby Crowned Kinglet	21	10	20	51	0.075	0.040	0.076	0.066
Red-winged Blackbird	353	203	228	784	1.261	0.806	0.864	1.010
Savannah Sparrow		2		2	0.000	0.008	0.000	0.003
Sora		2	3	5	0.000	0.008	0.011	0.006
Song Sparrow	476	395	419	1290	1.700	1.567	1.587	1.662
Solitary Vireo	5	13	4	22	0.018	0.052	0.015	0.028
Spotted Sandpiper	3			3	0.011	0.000	0.000	0.004
Sharp-shinned Hawk	4			4	0.014	0.000	0.000	0.005
Steller's Jay	33	67	89	189	0.118	0.266	0.337	0.244
Swainson's Thrush	154	181	344	679	0.550	0.718	1.303	0.875
Townsend's Warbler	38	2	13	53	0.136	0.008	0.049	0.068
Tree Swallow	101	63	67	231	0.361	0.250	0.254	0.298
Varied Thrush	41			41	0.146	0.000	0.000	0.053
Vaux's Swift	18	13	8	39	0.064	0.052	0.030	0.050
Violet-green Swallow	56	68	151	275	0.200	0.270	0.572	0.354
Virginia Rail	9	3	6	18	0.032	0.012	0.023	0.023
Warbling Vireo	38	3	22	63	0.136	0.012	0.083	0.081
White-crowned Sparrow	14	9	1	24	0.050	0.036	0.004	0.031
Western Tanager	17	9	29	55	0.061	0.036	0.110	0.071
Western Wood-pewee	11	6	13	30	0.039	0.024	0.049	0.039
Willow Flycatcher	116	90	142	348	0.414	0.357	0.538	0.448
Wilson's Warbler	115	72	78	265	0.411	0.286	0.295	0.341
Winter Wren	109	85	115	309	0.389	0.337	0.436	0.398
Wood Duck	10	4	9	23	0.036	0.016	0.034	0.030
Yellow Warbler	67	50	26	143	0.239	0.198	0.098	0.184
Yellow-rumped Warbler	7	3	4	14	0.025	0.012	0.015	0.018
Totals	4203	3338	5215	12756	15.011	13.246	19.754	16.438