Effects of Thinning and Prescribed Burning on Ponderosa Pine Forest Birds on City of Boulder Open Space

2001 Year End Report

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31 December 2001

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Abstract

The foothill ponderosa pine forests along the Colorado Front Range are an important, unique and understudied habitat. Ponderosa pine forests are important to a variety of wildlife species, including Neotropical migrant and resident songbirds. Among the number of songbirds breeding in this habitat are several species considered sensitive to landscape changes that could increase rates of nest predation and Brown-headed Cowbird (*Molothrus ater*) parasitism. Specific stands of ponderosa pine on City of Boulder Open Space are slated for thinning and/or burning to "maintain or enhance native plant and animal species, their communities, and the ecological processes that sustain them" (Goal #1 *of* City of Boulder Forest Ecosystem Management Plan 1999, p. iii). As part of this goal, in the spring and summer of 2000, we set up 6 study sites (2 control, 2 thinning and burning, and 2 burning). During 2000 and 2001 we gathered pre-treatment baseline data on abundance, diversity and nesting success of Neotropical migrant and resident birds. Our data on 141 nests, territory information for the breeding season, and abundance data during spring, fall and winter provide insightful baseline information for use in future comparisons after treatment. In addition, our data suggest the nature of the bird community present in the plots, and the appropriate management for enhancing this community. Our data show that two of the plots, S3 North and S3 South have a depauperate avian community and low rate of nesting. As a result, they offer a great opportunity for use of more intensive management. Watertank West and Watertank East plots show a diverse and abundance breeding bird community so lower intensity management will be appropriate for these stands. Finally, D2 and D3/D4 will serve as appropriate controls for these four treatment stands in future comparisons of bird community responses to treatment.

Introduction

Foothill ponderosa pine (*Pinus ponderosa*) is widely distributed along the Colorado Front Range, extending north and south along the entire length of the state (Little 1971). It can be characterized by a park-like appearance of open canopy ponderosa pine, scattered Douglas fir (*Psuedotsuga menziesii*), and an understory composed of five major plant associations including shrubs, herbaceous plants, mixed grass and rock outcrops (Forest Ecosystem Management Plan 1999). A number of Neotropical migrants breed in ponderosa pine and adjacent montane riparian and shrubland habitats of Boulder County, including the Broad-tailed Hummingbird (*Selasphorus platycercus*), Blue-gray Gnatcatcher (*Polioptila caerulea*), Western Wood-pewee (*Contopus sordidulus*), Hammond's Flycatcher (*Empidonax hammondii*), Dusky Flycatcher (*E. oberholseri*), Cordilleran Flycatcher (*E. occidentalis)*, Plumbeous Vireo (*Vireo Plumbeus*), Warbling Vireo (*Vireo gilvus*), Virginia's Warbler (*Vermivora virginiae*), Audubon's Warbler (*Dendroica coronata*), MacGillivray's Warbler (*Oporornis tolmiei*), Western Tanager (*Piranga ludoviciana*), Black-headed Grosbeak (*Pheucticus melanocephalus*), Spotted Towhee (*Pipilo macalatus*), Green-tailed Towhee (*P. chlorurus*), and Chipping Sparrow (*Spizella passerina*) (Cruz et al. 1999). Many of these species are considered sensitive across their southwestern range.

In addition to the sensitive breeding Neotropical migrant species, there are a also a number of migratory species that use ponderosa pine forests during the refueling of their migratory flights in the Spring and Fall. Many of these are members of populations listed above. Migration is a period of exceptional energy demands and small songbirds are generally incapable of storing enough fat reserves for a non-stop migration flight (Berthold 1975, 1993). Therefore, the availability of suitable habitats where depleted fat stores can be safely and rapidly replenished becomes critical to a successful migration (Moore et al. 1995). The fruiting shrubs of the ponderosa pine understory may be an important resource for songbirds during the fall migration. As a result, timing and use of the ponderosa pine forest by fall and spring migrants is important to monitor.

Years of fire suppression in the foothills of Boulder County have had a pronounced effect on the forest-grassland interface, and on the forest ecosystem itself. The ponderosa pine forest occurs at a lower elevation than historically (Veblen and Lorenz 1991), and the stand is overstocked with a high density of trees, making the forest more susceptible to catastrophic fires and pine beetle infestations (Forest Ecosystem Management Plan 1999). The proposed thinning and burning of ponderosa pine forests on City of Boulder Open Space should restore large-scale disturbance process that will dramatically alter the age-structure of the ponderosa pine forest. In turn, these changes should support a higher avian species diversity and maintain more stable populations of open-forest aerial insectivores, granivores, and tree-drilling bird species (Marshall 1963, Hejl 1994, Finch et al. 1997).

This situation presents a unique opportunity to experimentally study the effects of fire and thinning on ponderosa pine forest birds. In order to address this, in 2000 and 2001 we began a

study that will not only provide direct monitoring for the City of Boulder Open Space and Mountain Parks Department, but also provide a model by which southwestern pine forest managers can *a priori* evaluate the impacts of these techniques on the bird community. We have monitored the response of Neotropical migrants during the breeding season, resident birds during the winter, obtained demographic information (e.g., nest success, productivity), and evaluated the ponderosa pine forests as stop-over habitat during spring and fall migration. We have collected baseline data before any treatment took place so that in the future, we can measure the responses of the resident bird community to forest burning and thinning.

Methods

Study sites

During the spring and early summer of 2000, we established six study sites with the assistance of City of Boulder staff. We selected plots based on the City of Boulder Management plan to include plots that are slated for thinning and burning, burning only, and no treatment. Our two control plots are 5.5 and 9.75 ha respectively and are located in the D-2 and D3/D4 stands. Our two burning only stands are located in the Watertank (WTE and WTW from here on) stand and are 11.5 and 10.75 ha each. Our two burning and thinning plots are located within the S3 stand (S3S and S3N) and are 6 and 5.25 ha respectively. We marked each plot with a grid pattern consisting of 50m x 50m cells. We marked all corners within the grid using aluminum tree tags.

Breeding Productivity

We located a total of 90 nests in 2000 and 99 nests in 2001 on the six study plots by observing nesting behavior (Ralph et al. 1993). Once found, we marked nests with a small blue flag > 10 m from the nest. Each nest was monitored at least once every three days from the day it was found until the nest was inactive. We observed nest contents directly or with a 6-m mirror pole. Efforts were made to not attract nest predators to the nest site (Picozzi 1975, Westmoreland and Best 1985, Major 1989). Following nest inactivity, vegetative parameters were measured following James and Shugart (1970), and as modified for the standardized protocol (BBIRD) developed by Martin and Ropper (1988). In addition, we measured distances from the nest to human impacts: trails, roads, homes, canopy openings, power line right-of-ways, and livestock. We have extensive experience with all of the methods involved with nest finding and monitoring, and to the best of our ability we attempted not to interfere with the nesting success of any species.

Avian Censusing

In order to measure avian abundance and diversity on the study plots, we used spot mapping. We completed maps by walking the 50-m grid lines on each plot between 0600-1000 six times during the breeding season fall migration, winter and spring migration. Each encounter with an individual was recorded as a location on the map along with the behavior of the individual. This

information allowed us to create single-species maps of each of the study sites for the six-week census period. This provided estimates of the minimum number of territories during the breeding season, or number of individuals detected during migration and the winter. Data from fall, winter, and spring mapping were converted to average estimates of encounters for each species per hour of observation time on each plot. This was calculated using:

$$\frac{\text{Total number of observations for each species}}{\text{Total hours of observation on the study plot for census period}}$$

Data from winter spot mapping to be collected in January-February 2002 and spring migration to be collected during April-May of 2002 will be added as an appendix following data collection.

Results

Breeding Productivity

Overall, we monitored a total of 189 nests of 20 different species. We had concrete success/failure data on 141 of those. The data on nest success as well as rate of parasitism and predation is presented in Tables 1-6. Overall, on all six plots for both years combined, 67 % (59% in 2000 and 76% in 2001) of the nests were successful at fledging at least one young, 16 % (14% in 2000 and 19 % in 2001) were preyed upon and another 15 % (26% in 2000 and .03 % in 2001) failed for reasons ranging from abandonment of the nest to mortality of the young due to exposure or other factors. Ten of the species we monitored are known to be suitable hosts for cowbirds. We monitored a total of 74 nests in 2000 and 2001 of these ten species. Interestingly, we found only 10 nests that were parasitized on all of the plots (1 in 2000 and 9 in 2001). This rate is much lower than that found by Cruz et al. (2000) in Boulder Mountain Parks between 1997-2000. The S3N and S3S plots had the highest overall nest success with 80% on S3N and 76.9% on S3S of the nests fledging young. However, only 5 nests were located on S3N and 13 nests were located on S3S during both study years. D-2 showed a rate of 72% success while D3/4 and WTW showed 71.4% and 65.2% of the nests fledging young. The lowest level of nest success was on the WTE plot with only 50% of the nests fledging young.

Because success rates vary between species, the overall success rate of a plot may be influenced by the species composition present. Examining a single species, the Western Wood-pewee, we found that the highest nest success was on S3S with 80% of the nests fledging young. However, this data is based only on 2001 nests since no Western Wood-pewee nests were located on this plot in 2000. The two control plots, D2 and D3/4 showed the highest nest success for pewees with 75% and 64% success respectively for both years. WTE showed 42% success while WTW had the lowest success rate with only 33% of the nests fledging young. No Western Wood-pewee nests were located on S3N in either year.

Avian Abundance and Diversity

Breeding season avian species abundance and diversity data are shown in Tables 7 and 8 as number of territories/hectare for each species by plot. The WTW plot showed the highest species diversity during the breeding season based on species with territories within the plot for both years. The lowest overall diversity during the breeding season was on the S3N plot followed by the S3S plot. These plots show only a few species that are mostly resident species and bark-foraging birds. Overall, D2, D3/D4, WTW and WTE show the highest territory density with S3S and S3N showing the lowest number of territories per hectare.

Fall migration abundance and diversity data are shown in Tables 9 and 10. Each species is represented by a measure of average observations/hour on each plot. These data show that the two plots S3S and S3N support a lower number of migratory species during this period during both 2000 and 2001. S3S shows a total of 14 species in 2000 and 15 species in 2001 while S3N shows 11 species in 2000 and 8 species in 2001. The other four plots D2, D3/D4, WTE, WTW all show a large number of species using the plots during fall migration ranging from an overall average of 23.5 species on WTE (19 in 2000, 28 in 2001) to an average of 18.5 on D2 (18 in 2000 and 19 in 2001).

Spring migration data shows a similar trend in 2001 with S3N and S3S showing lower overall numbers of species (14 for S3N and 12 for S3S) while the four remaining plots, D2 (22), D3/4 (29), WTE (26) and WTW (23) show high numbers of species using the plots (See Table 11).

Winter census data show the lowest number of species being found in S3N (6). However, WTW also shows the second lowest number of species with only 8 during 2001. D2, D4/3 and WTE showed the largest number of species during the winter period with 11, 13 and 11 respectively (Table 12)

Conclusions

The data we collected during 2000 and 2001 provide a baseline from which to compare post-treatment avian communities and reproductive success. However, these two years of data do allow some preliminary comparison between sites. Perhaps the most striking feature of the nesting data is the low number of nests in the S3S and S3N sites. In addition, the number of nesting species located was limited to four on S3N and seven on S3S. The possible reasons for this lie in the structure of these sites. The even-age structure and lack of understory structure and diversity provide a limited number of nesting resources, ideal for only a few species. Most nests located in 2001 on the S3S site were located near the southeast corner of the stand. This area is characterized by a more open canopy with complex understory vegetation and a diverse age structure. As a result, it offers very different habitat than the remainder of the S3S plot. In fact, it had the highest success rate when the 5 Western Wood-pewee nests we monitored were examined. Interestingly, D2 that had the next highest overall success rate of nests also has the highest predation rate in both 2000 and 2001. One

reason for this may be the open nature of part of the D2 plot. In addition, its high edge-interior ratio due to its mesa-top characteristic may provide access to more corvid nest predators using surrounding habitats than the other plots. D3 and WTW both have a diverse nesting community with an intermediate success rate. The diversity of nesting species suggests that these plots provide a variety of nesting resources attracting both understory and overstory nesting birds. The WTE plot also showed a high diversity of nesting species. However, it had the lowest success rate of all the plots in both 2000 and 20001. The reasons for this are unclear with low rates of predation and a high level of abandonment. Examination of Western Wood-pewee nest success shows a similar, but not identical pattern to the overall nesting success on each plot. This suggests that species responses to various forest structures may differ and the species composition of a plot may greatly influence its overall nesting success.

Breeding season data on territories also show some interesting trends between study plots. Similar to the nesting data, number of territories during the breeding season were very low in the S3N and S3S plots. Again, this can be explained by the dense nature of these stands and the uniform and low diversity nature of resources available to birds, especially in the understory. The higher number of species with territories with S3S is again probably due to the more complex structure of the southeast corner of this plot. D2, D3/D4, WTE and WTW all show high diversity and abundance of territorial birds. As a result, we conclude that these plots provide a diverse habitat and resources necessary for forest birds. Results are similar during the fall and spring migration period. S3N and S3S both show low numbers of migratory species using the plots. This suggests that the forest on the plots does not have resources necessary for migratory species moving through the region. However, the remaining four plots, D2, D3/4, WTE and WTW all show a large numbers of species using these plots during migration periods. During the winter, none of the plots show diverse avian communities or high abundances of resident birds. However, D2, D3/4, and WTE all support the highest diversity of birds during this time of year.

Inter-annual differences are apparent in all data collected in 2000 and 2001. However, overall trends of forest bird use of these plots are maintained across years. As a result, we are confident that the data collected over the two years provides a valuable and accurate assessment of the forest bird communities in these ponderosa pine forests.

These data provide some insight into the best management plans for these sites. First of all, it is very clear from these findings that S3S and S3N do not provide good habitat for use by most forest birds. As a result, to increase the use of these forests by a diversity of bird species, particularly neotropical migrants, these plots should be treated with more intense management techniques. Extensive thinning will be necessary to mimic the type of forest structure present in the other plots that show a broader avian community. However, the southeastern corner of the S3S plot provides a more diverse forest structure and shows higher use by forest birds both for breeding and during migration times. In fact, preliminary vegetation data collected at random points within

the plots indicate that S3S most closely resembles the D2 plot in its forest structure, primarily due to the openness seen at the southeast corner. As a result, this area may not require the intense management recommended in the rest of the S3 stand.

The high diversity and abundance in the WTE and WTW plots show that these plots are more effective at providing habitat for songbirds during the breeding season as well as during migration. This suggests that management of these stands should be less severe perhaps with minimal thinning and low intensity, low heat fire. This treatment would be predicted to enhance the diversity of resources available for forest birds without sacrificing the existence of denser areas as well as more open areas. Also within the Watertank stand, the forest structure varies from very open on WTE to quite dense on the western side of WTW. As a result, varying management intensity across the plot may provide the best habitat for forest bird use. Because understory structure seems to be important to many birds, high mortality of shrub roots and seed banks should be avoided by maintaining low intensity of any treatment fires.

The control plots, D2 and D3/D4 also show high diversity and abundance of forest birds with an active breeding bird community with high success of nests. The high level of predation on the D2 plot shows the possible effects of fragmentation and forest edges in increasing predation of open cup nesting species. However, given these limitations of the D2 plot, D2 and D3/D4 appear to provide an excellent control for sites that will be treated with burning and or thinning. These sites both show a diversity of forest structure from more dense areas to open savanna-like forest. As a result, we suggest that these are not treated and left as reference areas that can be used as controls against which to compare the plots that will be treated.

The data that we collected during 2000 and 2001 provide baseline data for the six plots that we have set up. Following treatment of the four plots S3N, S3S, WTE and WTW these data will allow us to compare changes in the forest bird community within each plot. In addition, collection of two years of baseline data has allowed us to capture some of the inter-annual variation possible in the forest bird communities. This information will better allow us to compare future post-treatment data with the understanding of the variation possible due simply to differences between years. As a result, we will be able to make appropriate conclusions about the nature of the bird communities' response to management with appropriate control plots as well as baseline information on the community present in each plot prior to treatment.

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Table 1. Nest success of passerine birds on control plot D2- City of Boulder Open Space, 2000 and 2001.

Note: unreported outcomes are failures due to causes such as abandonment or death of young due to exposure

Species	N		Parasitism		Predation		Nest Success	
	2000	2001	2000	2001	2000	2001	2000	2001
American Robin	2	1	0%	0%	0%	100%	100%	0%
Black-capped Chickadee	1	0	0%	-	0%	-	100%	-
Blue-gray Gnatcatcher	1	1	0%	0%	0%	0%	100%	100%
Cedar Waxwing	0	1	-	0%	-	0%	-	100%
Chipping Sparrow	0	1	-	0%	-	100%	-	0%
Lesser Goldfinch	1	1	0%	0%	0%	0%	100%	100%
Mourning Dove	0	2	-	0%	-	100%	-	0%
Western Tanager	0	1	-	0%	-	0%	-	100%
Western Wood-pewee	4	8	0%	0%	25%	12%	50%	88%
Total	9	16	0%	0%	11%	31%	78%	69%

Table 2. Nest success of passerine birds on control plot D3/D4- City of Boulder Open Space, 2000 and 2001.

Note: unreported outcomes are failures due to causes such as abandonment or death of young due to exposure

Species	N		Parasitism		Predation		Nest Success	
	2000	2001	2000	2001	2000	2001	2000	2001
American Robin	2	1	0%	0%	0%	0%	100%	100%
Blue-gray Gnatcatcher	1	-	0%	-	0%	-	100%	-
Broad-tailed Hummingbird	5	4	0%	0%	20%	25%	80%	75%
Chipping Sparrow	3	2	0%	100%	33%	0%	33%	100%
Common Nighthawk	-	1	-	0%	-	0%	-	100%
Green-tailed Towhee	-	1	-	0%	-	0%	-	100%
Lesser Goldfinch	-	3	-	0%	-	0%	-	100%
Plumbeous Vireo	5	5	0%	20%	0%	0%	60%	100%
Pygmy Nuthatch	1	-	0%	-	0%	-	100%	-
Spotted Towhee	-	1	-	0%	-	100%	-	0%
Townsends Solitaire	-	1	-	0%	-	100%	-	0%
Western Tanager	3	3	0%	66%	66%	33%	0%	66%
Western Wood-pewee	9	5	0%	0%	33%	0%	45%	100%
Total	29	27	0%	18%	4%	15%	55%	89%

Table 3. Nest success of passerine birds on treatment plot WTE- City of Boulder Open Space, 2000 and 2001.

Note: unreported outcomes are failures due to causes such as abandonment or death of young due to exposure

Species	N		Parasitism		Predation		Nest Success	
	2000	2001	2000	2001	2000	2001	2000	2001
Black-capped Chickadee	2	-	0%	-	0%	-	100%	-
Blue-gray Gnatcatcher	1	-	0%	-	0%	-	0%	-
Chipping Sparrow	2	1	0%	100%	0%	0%	50%	0%
Cedar Waxwing	1	-	0%	-	0%	-	0%	-
Common Poorwill	-	1	-	0%	-	0%	-	100%
Mourning Dove	1	-	0%	-	0%	-	100%	-
Western Tanager	1	1	0%	0%	0%	0%	0%	100%
Western Wood-pewee	4	3	0%	0%	25%	0%	25%	66%
Total	12	6	0%	17%	8%	0%	42%	66%

Table 4. Nest success of passerine birds on treatment plot WTW- City of Boulder Open Space, 2000 and 2001.

Note: unreported outcomes are failures due to causes such as abandonment or death of young due to exposure

Species	N		Parasitism		Predation		Nest Success	
	2000	2001	2000	2001	2000	2001	2000	2001
American Robin	1	-	0%	-	0%	-	100%	-
Black-capped Chickadee	1	-	0%	-	0%	-	100%	-
Chipping Sparrow	3	-	0%	-	0%	-	33%	-
Mountain Chickadee	1	1	0%	0%	0%	0%	100%	100%
Mourning Dove	1	-	0%	-	0%	-	100%	-
Northern Flicker	1	-	0%	-	0%	-	100%	-
Plumbeous Vireo	1	2	100%	50%	0%	0%	0%	50%
Spotted Towhee	1	-	0%	-	100%	-	0%	-
Western Tanager	1	-	0%	-	0%	-	100%	-
Western Wood-pewee	5	4	0%	0%	0%	25%	0%	75%
Total	16	7	6%	14%	6%	14%	63%	71%

Table 5. Nest success of passerine birds on treatment plot S3N- City of Boulder Open Space, 2000 and 2001.

Note: unreported outcomes are failures due to causes such as abandonment or death of young due to exposure

Species	N		Parasitism		Predation		Nest Success	
	2000	2001	2000	2001	2000	2001	2000	2001
Chipping Sparrow	-	1	-	0%	-	0%	-	100%
Common Poorwill	1	-	0%	-	0%	-	0%	-
Mountain Chickadee	2	-	0%	-	0%	-	100%	-
Townsends Solitaire	1	-	0%	-	0%	-	100%	-
Total	4	1	0%	0%	0%	0%	75%	100%

Table 6. Nest success of passerine birds on treatment plot S3S- City of Boulder Open Space, 2000 and 2001.

Note: unreported outcomes are failures due to causes such as abandonment or death of young due to exposure

Species	N		Parasitism		Predation		Nest Success	
	2000	2001	2000	2001	2000	2001	2000	2001
Broad-tailed Hummingbird	-	2	-	0%	-	50%	-	50%
Common Poorwill	-	1	-	0%	-	0%	-	100%
Chipping Sparrow	1	-	0%	-	0%	-	100%	-
Mourning Dove	-	1	-	0%	-	0%	-	100%
Plumbeous Vireo	-	1	-	100%	-	0%	-	100%
Townsends Solitaire	-	2	-	0%	-	50%	-	50%
Western Wood-pewee	-	5	-	0%	-	20%	-	80%
Total	1	12	0%	8%	0%	25%	100%	75%

Table 7. Number of territories/ha by site during 2000 breeding season for all six sites- City of Boulder Open Space, 2000.

Species	Number of Territories					
	D2	D3/D4	WTE	WTW	S3N	S3S
American Robin	0.90	0.41	0.17	0.47	0	0
Black-capped Chickadee	0.36	0.51	0.35	0.19	0.19	0.33
Blue-gray Gnatcatcher	0.36	0	0	0	0	0
Broad-tailed Hummingbird	0	0.51	0	0.37	0	0
Cedar Waxwing	0.18	0	0.26	0	0	0
Chipping Sparrow	0.55	0.61	0.70	0.47	0	0.66
Hammond's Flycatcher	0	0	0	0.09	0	0
House Finch	0.36	0.21	0.26	0.37	0	0
Lesser Goldfinch	0.36	0.51	0.44	0.19	0	0.33
MacGillivray's Warbler	0	0.10	0	0	0	0
Mountain Chickadee	0.73	0.10	0.09	0.47	0.76	0.5
Mourning Dove	0.55	0	0.35	0.47	0	0
Northern Flicker	0	0	0	0.19	0	0
Plumbeous Vireo	0	0.62	0.26	0.47	0	0.16
Pygmy Nuthatch	0.36	0.31	0.17	0.47	0.70	0.33
Spotted Towhee	0.36	0.82	0.52	0.93	0	0
White-breasted Nuthatch	0.36	0.41	0.17	0.65	0.70	0.5
Western Tanager	0.18	0.72	0.26	0.47	0.19	0
Western Wood-pewee	1.10	1.03	0.70	1.02	0.57	0.83

Table 8. Number of territories/ha by site during 2001 breeding season for all six sites- City of Boulder Open Space, 2000.

Species	Number of Territories					
	D2	D3/D4	WTE	WTW	S3N	S3S
American Robin	0.36	0.31	0.09	0.09		
Blue-gray Gnatcatcher	0.55		0.09			
Chipping Sparrow	0.36	0.92	0.70	0.47		0.33
Hammond's Flycatcher				0.09		
House Finch		0.10	0.35	0.09		
Lesser Goldfinch	0.18	0.72	0.26			
Mountain Chickadee	0.18	0.10	0.09	0.09	0.38	
Mourning Dove	0.36		0.17	0.09		0.17
Plumbeous Vireo		0.51		0.19		0.17
Pygmy Nuthatch	0.18	0.31			0.19	
Spotted Towhee	1.27	0.41	0.26	0.28		0.17
Townsends Solitaire					0.19	0.5
Western Tanager		0.51	0.17	0.37		0.16
Western Wood-pewee	1.45	0.62	0.78	0.65		0.83

Table 9. Mean number of observations per hour of all species by plot during fall migration- City of Boulder Open Space, 2000

Species	Mean number of observations/hour					
	D2	D3/D4	WTE	WTW	S3N	S3S
American Goldfinch	0	0.9	2.1	0.15	0	0
American Robin	3.0	17.7	6.4	2.1	2.4	2.13
Black-capped Chickadee	5.1	0.5	2.7	1.1	1.33	0.53
Brown Creeper	0	0.62	0.9	1.28	0.13	0.67
Cedar Waxwing	0.43	0	0	0	0	0
Chipping Sparrow	1.48	2.8	0.7	.23	0	0.40
Dark-eyed Junco	0.87	2.7	4.7	1.5	0	0.13
Golden-crowned Kinglet	0	0	0	0.4	0	0
House Finch	2.69	2.7	2.4	.53	0	0
Lesser Goldfinch	0.17	3.2	0.9	0	0.27	0.40
MacGillivray's Warbler	0	0.08	0	0	0	0
Mountain Chickadee	0.96	8.88	1.3	3.5	3.47	5.87
Mourning Dove	0	0	0.13	0.15	0	0
Northern Flicker	0.52	2.04	0.9	0.23	0.27	0.53
Pine Siskin	3.13	0.98	0.5	0.15	0	0
Plumbeous Vireo	0	0.71	0	0.23	0.13	0.27
Pygmy Nuthatch	7.1	6.5	2.5	3.9	6.0	6.7
Red-breasted Nuthatch	0.17	6.93	0.4	0.45	1.33	0.27
Ruby-crowned Kinglet	0.26	0.8	1.5	0.6	0	0
Spotted Towhee	1.74	1.5	1.7	1.2	0	0.4
Townsends Solitaire	0.35	5.25	0.3	0.08	0.53	2.4
White-breasted Nuthatch	3.6	2.22	2.0	2.2	2.67	2.8
Yellow-rumped Warbler	0.35	0.8	0.4	0.53	0	0
Western Wood-pewee	0.08	0.09	0	0	0	0

Table 10. Mean number of observations per hour of all species by plot during fall migration- City of Boulder Open Space, 2001

Species	Mean number of observations/hour					
	D2	D3/D4	WTE	WTW	S3N	S3S
American Crow	0	0.08	0	0	0	0
American Robin	0	0.62	0	0.23	1.4	0
Black-billed Magpie	0	0.16	0	0	0	0
Black-capped Chickadee	1.21	0	3.02	0	0	0
Blue-gray Gnatcatcher	0	0	0.16	0.08	0	0
Blue Jay	0.24	0	0.95	0.31	0	0.19
Broad-tailed Hummingbird	0	0.78	0.08	0.46	0	0.78
Brown Creeper	0.12	0	0.24	0.31	0	0.19
Bush Tit	0	0.08	0	0	0	0
Chipping Sparrow	15.39	3.18	4.60	5.54	0.46	6.21
Common Nighthawk	0.12	0	0	0	0	0
Common Poorwill	0	0	0.08	0.08	0	0
Common Raven	0	0.16	0.08	0	0	0
Dark-eyed Junco	0	0	0	0.15	0	0
Downy Woodpecker	0.12	0.08	0.16	0	0	0
Green-tailed Towhee	0	0	0.40	0	0	0
Hairy Woodpecker	0	0	0.08	0	0	0
House Finch	0	0	0	0.08	0	0
Lesser Goldfinch	0.61	1.0	0.08	0.77	0	0
Mountain Bluebird	0	0	0.08	0	0	0
Mountain Chickadee	3.88	4.26	3.17	6.46	7.13	9.32
Mourning Dove	0	0.08	0.63	0	0	0
Northern Flicker	0.85	0.31	0.48	0.38	0.23	0.19
Plumbeous Vireo	0	1.09	0.08	0.38	0	0.78
Pygmy Nuthatch	5.45	8.84	2.54	6.08	4.14	3.88
Red Crossbill	0	0.16	0	0	0	0

Red-breasted Nuthatch	1.82	5.12	3.02	2.85	3.21	1.94
Ruby-crowned Kinglet	0	0	0.08	0.08	0	0
Spotted Towhee	1.33	0.16	1.19	1.08	0	0.39
Stellar's Jay	2.55	4.8	2.94	3.92	2.07	2.72
Townsends Solitaire	0.12	0.70	0.24	0	0	0
Townsends Warbler	0	0.08	0	0.08	0	0
Virginias Warbler	0.36	0	0.08	0	0	0
Western Meadowlark	0.73	0.08	0.63	0	0	0
Western Tanager	0.12	0.08	0	0	0	0.19
Western Wood-pewee	0	0.23	0.24	0.38	0	0.19
White-breasted Nuthatch	4.24	2.17	1.83	2.08	2.07	1.94
White-crowned Sparrow	0.12	0	0	0	0	0
Yellow-rumped Warbler	0	0	0.08	0	0	0.19

Table 11. Mean number of observations per hour of all species by plot during spring migration-City of Boulder Open Space, 2001

Species	Mean number of observations/hour					
	D2	D3/D4	WTE	WTW	S3N	S3S
American Crow	0.12	0	0.62	0	0	0
American Goldfinch	0	0	0.18	0	0	0
American Robin	3.10	2.54	2.22	1.96	0.23	0
Black-billed Magpie	0.36	0.12	0.98	0.36	0	0
Black-capped Chickadee	0	1.15	0.54	0.44	0	0
Blue-gray Gnatcatcher	0.48	0.23	0.18	0	0	0
Broad-tailed Hummingbird	0.36	0.46	0.62	1.07	0.23	0.21
Brown Creeper	0	0	0	0.98	0	0
Brown-headed Cowbird	0.60	0.69	2.58	0.71	0	0
Chipping Sparrow	4.17	8.9	9.96	8.98	0.69	7.87
Common Raven	0	0.12	0	0	0	0
Dark-eyed Junco	0	0.23	0	0	0	0
Downy Woodpecker	0	0	0	0	0.46	0
Dusky Flycatcher	0	0.46	0	0	0	0
Green-tailed Towhee	0	0.12	0	0	0	0
Hairy Woodpecker	0	0.12	0	0	0	0
Hammond's Flycatcher	0	0.12	0	0	0.23	0
House Finch	0.24	2.43	2.58	3.29	0	1.91
House Wren	0	0	0.09	0.18	0	0
Lesser Goldfinch	0.36	0	1.16	0.53	0	0
Mountain Chickadee	1.19	0.69	3.2	3.47	1.84	2.13
Mourning Dove	0.48	1.62	1.51	0.98	1.61	0.43
Northern Flicker	0	0.92	0.27	0.08	0.46	0
Pine Siskin	0	0.92	0	0	0	0
Plumbeous Vireo	0.12	2.89	0	0.89	0	0.64
Pygmy Nuthatch	0.36	1.04	0.09	0.09	2.30	1.91

Red-breasted Nuthatch	0.48	0.23	0.36	0.53	0	0
Rock Wren	0	0	0	0	0	0.21
Ruby-crowned Kinglet	0.12	0.12	0	0	0	0
Spotted Towhee	3.57	3.35	3.11	1.07	0	0
Stellar's Jay	2.38	1.73	0.89	1.51	1.61	0.85
Townsends Solitaire	0	0.46	0.09	0.36	0.46	1.49
Warbling Vireo	0	0	0	0.18	0	0
Western Meadowlark	0.36	0	0.09	0	0	0
Western Tanager	0.48	1.50	0.62	2.22	0.69	0.43
Western Wood-pewee	0.12	2.31	0.44	1.69	0.23	0
White-breasted Nuthatch	0.71	0.81	0.89	1.16	0.46	0.21
Yellow-breasted Chat	0	0	0.09	0	0	0
Yellow-rumped Warbler	0.24	0.92	1.24	0	0	0

Table 12. Mean number of observations per hour of all species by plot during winter- City of Boulder Open Space, 2001

Species	Mean number of observations/hour					
	D2	D3/D4	WTE	WTW	S3N	S3S
American Crow	0	0.13	0	0	0	0
American Robin	0	0.25	0	0	0	0
Black-billed Magpie	2.68	0	1.01	0.45	0.20	0
Black-capped Chickadee	2.27	1.27	0.29	0	0	0
Brown Creeper	0	0	0.14	0	0.20	0.17
Common Raven	0.21	0.25	0	0	0	0
Dark-eyed Junco	0.21	0.38	1.9	0	0.59	0.17
Great-horned Owl	0	0	0	0	0	0
Hairy Woodpecker	0	0	0.14	0.15	0	0
House Finch	0.41	0.25	0.14	0.15	0	1.03
Mountain Chickadee	2.06	1.27	3.48	3.64	0.39	0.36
Northern Flicker	0.41	0.12	0.14	0.15	0.20	0.17
Pine Siskin	0	0.25	0	0	0	0.52
Pygmy Nuthatch	3.92	1.27	0.43	1.97	0	1.72
Stellar's Jay	0.82	0.51	1.9	1.21	0	0.17
Townsends Solitaire	0.82	0.63	0	0	0	0.51
White-breasted Nuthatch	0.62	0.25	0.29	0.91	0.39	1.72