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Distribution, Abundance, Nest Site Characteristics, and Reproductive Success of Selected Avian Taxa on Forested City of Boulder Open Space and Mountain Parks Properties

Research Summary and Final Report

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Distribution, Abundance, Nest Site Characteristics, and Reproductive Success of Selected Avian Taxa on Forested City of Boulder Open Space and Mountain Parks Properties 1999 – 2001.

Introduction: From 1999 through 2001 we have been involved in a study of the distribution, abundance, and reproductive success of open-cup nesting birds on City of Boulder Open Space and Mountain Parks properties. Our studies in the core area of Boulder Mountain Parks involved two broad areas. The first focal area of our research involved determination of avian distribution and abundance on the properties through pointcounts taken at different locations scattered across the properties. The number of counts varied from year to year but included up to 51 Avian Monitoring Points (AMP's) determined by Boulder Mountain Parks personnel and up to 85 additional points set up by members of the Cruz laboratory at the University of Colorado for a variety of studies. The second focal area of our research involved the location and monitoring of over 300 nests in a number of locations across the properties. These locations varied from year to year but included Enchanted Mesa, Bluebell Mesa, and Gregory Canyon in Boulder Mountain Parks and the following plots on City of Boulder Open Space; D2, D3/D4, Water Tank East and West, S3 North and South, and North Lindsay. Please see our 1999, 2000, and 2001 reports to Boulder Mountain Parks and to City of Boulder Open Space for details on exact locations of our research and results of those field seasons (additional copies are available on request).

This document is meant to be both a final report on our research activities funded by Boulder Mountain Parks Avian Monitoring Program from 1999 through 2001 as well as a summary of much of the results of this research. Although we are continuing work with City of Boulder Open Space and Mountain Parks, we expect no further funding or research involving monies from the Boulder Mountain Parks Avian Monitoring Program. The following species accounts and tabular data are meant to assist wildlife managers in assessing the health of open-cup nesting bird populations across those City of Boulder Open Space and Mountain Parks properties that are covered by ponderosa pine and mixed conifer forest types. These accounts include a summary of all of our knowledge of the abundance and nesting success of 15 open-cup nesting bird species commonly encountered on these properties and predictions about how forest management practices might affect those species. In addition, on a separate CD-Rom, we have included GIS output maps of predicted distribution of a limited number of species for which landscape-level variables appear to affect distribution and abundance. The following pages outline the major topics covered in each table and species account and provide information helpful to interpreting the data.

Distribution and Abundance: Means and standard deviations of the relative abundance (hereafter RA) of avian taxa in 3 forest types (low elevation riparian, ponderosa pine, and mixed conifer) are provided in Table 1. Species are considered abundant if RA exceeds 0.8 pairs/ha, common if RA is between 0.4 and 0.8 pairs/ha, uncommon if RA is between 0.2 and 0.4 pairs/ha, and rare if RA is between 0.1 and 0.2 pairs/ha. RA indices of less than 0.1 pair/ha are not reported as these species are not considered to be an important part of the avifauna in a particular habitat. All data come from 50 m fixed-radius circular plot

point counts (Hutto et al., 1986; Ralph et al., 1993) undertaken 3 times per year during the years 1999-2001. For more details on the methodology see our annual reports to City of Boulder Open Space and Mountain Parks.

Predictive species models were created for some species using linear regression and the Arcview Geographic Information System. These models are provided on a separate CD-Rom and were created whenever physiographic (elevation, slope, aspect, distance to streams), or human disturbance (distance to roads, trails, or habitation) appeared to strongly influence the distribution of a species. Models are of two types; abundance and probability of detection. Abundance models are used for most species but a probability of detection model was created for the Brown-headed Cowbird *(Molothrus ater),* which is not territorial . In order for a model to be included, the overall model must be statistically significant at the $\alpha <$ 0.05 level and have an R^2 value of at least 0.20. Individual parameters within the model must also be statistically significant at the $\alpha < 0.1$ level and add at least 0.05 to the R^2 value. Stand structure data (stand density, shrub density, etc.) were not used in the models due to the inadequacy of currently available GIS layers incorporating these data. If adequate layers were created it is expected that many of the predictive models would be significantly improved.

Breeding Phenology: Figure 1 and Table 2 include data on the timing of breeding of avian taxa in the study area. The breeding period was predicted using unparasitized nests that were known to have successfully fledged young and for which accurate dates are known for laying, hatching, and/or fledging. Incubation and nestling periods for nests with exact laying or fledging dates were determined using the data in Table 3 (see below). The breeding phenology data include the start of the breeding season (first nest active), the end of the breeding season (last nest active), and the dates between which at least 25% of nests were known to be active (1^{st} and 3^{rd} quartiles) and 50% of nests were known to be active (peak). Figure 1 shows the number of species (out of 14) breeding each each week between May 9 and August 20. Figure 2 shows the number of species (out of 10) for which at least 25% of the nests are active over the same time period. Quartiles and peak periods are not estimated for 4 species for which data are available on less than 10 nests. For both Table 2 and Figure 1, data from nests located all over Boulder County were used to increase sample size. None of these data would be expected to differ between city open space properties and county open space properties.

Nesting Success: Table 3 includes general data on the clutch size and nesting cycle for each species. Table 4 includes the outcome for all nests of known fate and an estimate of nesting success using the Mayfield method (Mayfield, 1975; Manolis.et al. 2000). Table 5 includes information on whether nests were parasitized by Brown-headed Cowbirds and an estimate of the rate of parasitism on each species. Estimates of nest success and rates of parasitism are not provided for Hammond's Flycatcher or Townsend's Solitaire as there was an insufficient number of nests for analysis. Table 3 includes data from nests outside City of Boulder Open Space and Mountain Parks (primarily from the Heil Ranch property owned by the county)

since these data would not be expected to differ at different sites. Data from Tables 4 and 5 are only from nests on City of Boulder Open Space and Mountain Parks properties, however, as these data may vary between city and county owned properties. In all cases data come from nests monitored by our field crew using standardized methods (Martin & Geupel, 1993; Ralph et al., 1993). Efforts were made to disturb nesting birds as little as possible to avoid biasing rates of nest failure (Gotmark, 1992; Major, 1989; Martin & Geupel, 1993). For more details on the methodology see our annual reports (1999, 2000) to City of Boulder Open Space and Mountain Parks.

Nest Site Selection: Tables 6 and 7 contain information about nest site selection by the various avian taxa. The data are provided in the form of 90% confidence intervals (mean $\pm$ 1 standard deviation). The confidence intervals for a habitat characteristic may be considered a "typical" range in which a species will nest as at least 90% of the nests should fall within that range. Table 6 includes data on 3 "macrohabitat" characteristics (mean height of canopy trees, percent shrub cover, and stand density) measured on an 11.3 m radius plot around the nest site. Table 7 includes 3 "microhabitat" characteristics measured at the nest site itself (percent canopy cover over the nest, the percent of the distance toward the tip of the branch at which the nest is placed, and the percent of the distance up the tree at which the nest is placed). Thus Table 6 provides measurements of the habitat around the nest while Table 7 gives information about the placement of the nest within the tree itself. Both of these tables include only data from City of Boulder Open Space and Mountain Parks properties as differences in habitat structure between city and county properties may influence nest site selection on those properties. All data were collected using standardized methods (James and Shugart, 1970, Martin & Roper, 1988). For more details on the methodology see our annual reports (1999, 2000) to City of Boulder Open Space and Mountain Parks.

Management Concerns: The section provides additional analysis of the data from the tables and the previous sections. It is designed to give a more detailed interpretation of the most important variables influencing the distribution and abundance of each species and guidelines that may help manage for those species. Particular attention is given to species that appear to respond negatively to roads and trails because the distribution and abundance of these species may be strongly influenced by various direct effects of human disturbance such as flushing (Knight and Cole, 1995), or indirect effects such as increases in predation associated with predators (Miller & Hobbs, 2000), and increases in cowbird parasitism (Chace et al., in prep). Extra attention is also given to those species that seem to have some specialized habitat requirements and could be affected by forest management practices.

Mourning Dove *(Zenaida macroura)*

Distribution and Abundance: This species is relatively rare throughout city open space (Table 1). It is found in low density in the Ponderosa Pine forest and is almost absent from other habitat types we surveyed. Our study suggests that it is much more abundant where human disturbance is low (e.g. the Heil Ranch property owned by Boulder County). GIS analysis failed to reveal any significant patterns in Mourning Dove distribution in relation to physiographic variables or human disturbance, possibly because they are rarely encountered on point counts.

Breeding Season: Mourning Doves breed from at least the middle of may until early August (Table 2). They have a relatively late peak, with most nests active during the first two weeks of July. Two broods appear possible, but most pairs probably only nest once.

Nesting Success: Mourning Doves always lay 2 eggs and have a nesting cycle of approximately 25 days (Table 3). This species is highly prone to abandoning nests when disturbed (Table 4). On Heil Ranch, where many more active nests have been located, approximately 40% of nests are abandoned despite efforts to minimize disturbance, and other studies have also linked high rates of nest abandonment to human disturbance (Westmoreland & Best, 1985). When nests are not abandoned, nesting success is high. This species would be a poor host for cowbird parasitism. We have not located any parasitized nests (Table 5), nor have any been found elsewhere in Colorado (Chace & Cruz, 1996).

Nest Site Selection: Mourning doves seem to be generalists in terms of nest site selection (Table 6). They nests in stands varying widely in height and density, and do not appear to either require or avoid shrubby areas. In City of Boulder Open Space and Mountain Parks, mourning doves normally nest around the midpoint of branches in the lower to middle sections of Ponderosa Pines (Table 7). On Heil Ranch, however, the majority of nests are located on the ground.

Management Concerns: The biggest concern for this species is its susceptibility to human disturbance. Mourning Doves are rare throughout City of Boulder Open Space and Mountain Parks, and almost absent from areas of high human visitation such as Enchanted Mesa. Both the scarcity of nests on city open space properties and the lack of nests found on the ground are probably related to the high rates of nest abandonment by this species when disturbed. Persistence of this species on open space properties is probably dependant on keeping human visitation low in some areas.

Broad-tailed Hummingbird *(Selasphorus platycercus)*

Distribution and Abundance: Abundant in riparian habitats and common throughout forested properties owned by City of Boulder Open Space and Mountain Parks (Table 1). GIS analysis suggests that in ponderosa pine habitat, Broad-tailed Hummingbirds are less common at higher elevation ($P = 0.008$), less common on south-facing slopes ($P = 0.016$), more common close to trails ($P = 0.028$), and more common on steep slopes ($P < 0.001$) (model $R^2 = 0.371$). These patterns probably have more to do with the distribution of food resources than with habitat requirements of the hummingbirds. Analysis failed to reveal significant patterns in hummingbird distribution in relation to landscape-level variables in mixed conifer habitats.

Breeding Season: Breeding begins by mid-May and continues until the middle of August (Table 2). The extended peak period lasts from mid-June through July. Breeding season may vary annually depending on food resources. Each female probably is only able to nest once a year.

Nesting Success: Broad-tailed Hummingbirds always lay two eggs and have an extended nesting cycle lasting over a month (Table 3). Females alone incubate the eggs and care for the nestlings and fledgelings. Nesting success is generally high (Table 4). This species would be unsuitable as a cowbird host and there are no records of parasitism around Boulder (Table 5) or elsewhere in Colorado (Chace & Cruz, 1996).

Nest Site Selection: Characteristics of the habitat around nest sites are highly variable (Table 5) and this species appears to be a generalist that will nest almost anywhere. Nests are almost always placed in areas of high canopy cover around the middle of branches in the lower parts of coniferous trees (Table 6). Most nests are on small spurs that come out from underneath the main branch; the main branch forming a roof over the nest.

Management Concerns: The primary concern for this species is probably nest failure due to forest thinning. The extended breeding period of this species coupled with its requirements for both floral and arthropod resources that vary considerably on an annual basis probably means this species can only attempt to breed once a year. Extensive cutting during the peak of the breeding season could reduce annual productivity dramatically on a local scale. However, thinning of forest stands could also increase the availability of flowers that grow in clearings. Hummingbirds appear to be quite tolerant of human disturbance and many nests have been found close to trails.

Western Wood-Pewee *(Contopus sordidulus)*

Distribution and Abundance: A common species in ponderosa pine forest in Boulder County, but rare in riparian areas and very rare and local in mixed coniferous forests (Table 1). In ponderosa pine habitat, GIS analysis reveals that wood-pewees become less common with increasing elevation ($P = 0.005$) and are less common on steep slopes ($P < 0.001$) (model $R^2 = 0.323$).

Breeding Season: Breeding takes place primarily from early June (rarely late May) through mid-August (Table 2). The peak of the season lies between late June and late July. Each pair probably only raises one brood, but pairs will renest after an early nest failure. Many late nests are probably second attempts after initial nest failure.

Nesting Success: Western Wood-Pewees lay from 2 to 4 eggs, but most nests contain 3 eggs (Table 3). The nesting period lasts approximately 1 month (Table 3). In general, nesting success is high (Table 4) with most failures occurring after the young have hatched. High nesting success was also reported by Chace et al. (1997) in other parts of Boulder County, and by Goguen and Mathews (2000) in northern New Mexico. We have not located parasitized nests on CBOS, although we have found 2 parasitized nests on the Heil Ranch property owned by the county. Western Wood-Pewee nests are parasitized about 6% of the time in northern New Mexico (Goguen & Mathews, 2000).

Nest Site Selection: Western Wood-Pewees prefer to nest in savannah or relatively open coniferous woodland (Table 6). Thick stands, especially doghair, do not contain nesting pewees. Pewees also appear to need some taller trees for their nest sites, but shrub cover is not a necessity (Table 6). Pewee nests tend to be placed near the midpoint of branches in areas of moderate to high canopy cover (Table 7). Most nests are placed in the lower portion of the nest tree (Table 7), and regression analysis reveals a strong positive correlation between the height of the lowest live branch of the nest tree and pewee nest height (d.f. $= 49$, $R^2 = 0.272$, $P < 0.001$). Pewees appear to nest higher near trails, however, and regression analysis reveals there is a strong negative correlation between nest height and distance to the nearest trail for nests within 100 m of trails (d.f. $= 27$, $R^2 = 0.427$, $P < 0.001$).

Management Concerns: There are few management concerns associated with the Western Wood-Pewee. This species is generally common in proper habitat and thinning of doghair and thicker forest stands should increase the availability of suitable habitat. The species is tolerant of disturbance, though it is not clear if there are any consequences associated with the increase in nest height near trails.

Hammond's Flycatcher *(Empidonax hammondii)*

Distribution and Abundance: This species is uncommon and local in mixed coniferous forest and rather rare and local in ponderosa pine forest in Boulder County (Table 1). Hammond's Flycatchers were primarily recorded on points on Enchanted and Bluebell Mesa and in Long Canyon. GIS analysis failed to find any significant relationships between physiographic variables and Hammond's Flycatcher abundance in ponderosa pine although when found in that habitat they appear to be limited to thicker stands with tall trees. In mixed coniferous habitat, Hammond's Flycatchers are more likely to be found close to streams ($P = 0.063$) and more likely to be found on north-facing slopes ($P = 0.009$) (model $R^2 = 0.282$).

Breeding Season: There is insufficient data for analysis. However, breeding takes place from at least late May until late July (Table 2). Due to the long nesting cycle each pair probably is only capable of raising a single brood.

Nesting Success: We have found Hammond's Flycatcher nests containing from 3 to 5 eggs. Mean clutch size is about 4 eggs (Table 3). The nesting cycle is quite long in this species, lasting over a month (Table 3). Although Hammond's Flycatchers were not previously recorded as a cowbird host in Colorado (Chace & Cruz, 1996; Sedgewick, 1998), in 2001 we located a parasitized nest on the Heil Ranch property and observed a Hammond's Flycatcher feeding a fledgeling cowbird on Enchanted Mesa. At this time, we have monitored too few nests to accurately assess nesting success and rates of parasitism in this area.

Nest Site Selection: We have encountered Hammond's Flycatcher nests almost exclusively in areas of very tall canopy (Table 6). This species does not appear to nest in open areas, and some nest sites have been found in stands that are quite thick (Table 6). Shrub cover does not appear to be important (Table 6). All nests we have located have been near the midportion of the nest tree in an area of high canopy cover (Table 7). Most have also been relatively close to the trunk of the tree (Table 7).

Management Concerns: Though our sample size is low, we believe this species may have some very specific habitat needs. Hammond's Flycatchers appear to only nest in relatively thick areas of ponderosa woodland with many larger trees (e.g. Enchanted Mesa). Extensive thinning, especially the cutting of larger trees, could seriously affect local populations. However, Hammond's Flycatchers are much more abundant in mixed conifer forest and ponderosa pine stands may not be their primary habitat in this region.

Blue-gray Gnatcatcher *(Polioptila caerulea)*

Distribution and Abundance: This species is a recent addition to the breeding avifauna of the northern Colorado Front Range (Walsh et al., 1998). It is uncommon to rare, and rather local, on City of Boulder Open Space and Mountain Parks properties and is not found in the same locations every year (Table 1). Gnatcatchers appear to be more common in areas containing large amounts of foothills shrubland such as the Rabbit Mountain and Hall Ranch properties owned by Boulder County (Prather, pers. obs.). We did not detect this species often enough on point counts to determine if there were significant relationships between its distribution and landscape-level physiographic variables.

Breeding Season: There are insufficient data for analysis. However, active nests have been found from late May through late July (Table 2). Multiple clutches may be possible, but we have no evidence for second broods.

Nesting Success: Nests have contained between 3 and 5 eggs with an average of about 4 (Table 3). The nesting cycle for this species is short, averaging only 24 days (Table 3). We estimate that about 50% of the nests of this species fail on CBOS (Table 4). Blue-gray Gnatcatchers are one of the most important host species for cowbirds in northern New Mexico, where 58% of nests are parasitized (Goguen & Mathews, 2000). However, gnatcatcher nests appear to be rarely parasitized in this area (Table 5). This may be because of their relative rarity and/or because they are a novel host in the region due to their recent range expansion.

Nest Site Selection: Blue-gray Gnatcatchers appear to prefer quite open forest stands for nesting (Table 1). The presence of at least some shrub cover appears to be important (Table 6), perhaps because the birds often feed in shrubs. We have located nests in a variety of substrates, including ponderosa pine trees, deciduous trees, and shrubs. When nesting in trees gnatcatchers seem to typically choose sites under moderate canopy cover near the midpoint of branches (Table 7). The lower portions of the trees appear to be preferred (Table 7).

Management Concerns: As this species is a recent arrival to the area and seems to be rather general in its habits, it is probably not a species of great concern. Gnatcatchers appear to tolerate disturbance, and we have located several nests near trails. Cowbird parasitism could be a problem in the future, as this is a major cause of nest failure in northern New Mexico (Goguen & Mathews, 1996).

American Robin *(Turdus migratorius)*

Distribution and Abundance: A common breeding species throughout forested properties owned by CBOS (Table 1). GIS analysis failed to reveal any significant patterns in rboin abundance in relation to physiographic variables.

Breeding Season: This is the earliest breeder among the species analyzed, with some nests active by mid-May (Table 2). The peak of the breeding season is also quite early and extends from late May through mid-June. Nests have been located as late as early August (Table 2). It is likely that later nests represent second broods.

Nesting Success: American Robins lay from 2 to 4 eggs, but most nests contain 3 eggs (Table 3). The nesting cycle lasts 25 days (Table 3), and some pairs appear to renest while still caring for dependant fledgelings. Robins have a fairly high rate of nest success (Table 4), and we have not found any evidence of parasitism by cowbirds on robin nests on CBOS (Table 5) or elsewhere Boulder County.

Nest Site Selection: American Robins show probably the greatest variation in nest site selection of the species analyzed. They nest in all types of habitats except for thicker woodland and forest (Table 6). We have located nests in many different substrates, including pines, deciduous trees, and shrubs. When nesting in pines, many nests are placed on a branch fork right next to the trunk, but nests have also been found at the tips of branches. Most robin nests are in the lower portion of trees (Table 7).

Management Concerns: American Robins are a very common breeding species throughout CBOS. We have no major concerns for this species. They are tolerant of disturbance, and we have located many nests near trails. This species could be significantly affected by thinning, and since they nest relatively early in the season some nests could be destroyed by late spring burns. However, this species can raise multiple broods and would probably quickly renest after early-season failure.

Townsend's Solitaire *(Myadestes townsendi)*

Distribution and Abundance: This is a rare species on CBOS properties dominated by mixed conifer forest (Table 1). In mixed conifer habitats, Townsend's Solitaires are less common on steep slopes ($P = 0.052$), less common on east-facing slopes ($P = 0.085$), and more common away from roads and trails ($P = 0.004$) (model $R^2 = 0.361$). Solitaires are almost absent in ponderosa pine forest, except in very thick stands with little human disturbance.

Breeding Season: There is insufficient data for analysis. However, active nests have been located from early June through early August (Table 2).

Nesting Success: Nests appear to typically contain 3 or 4 eggs (Table 3). The nesting cycle lasts about 26 days (Table 3). We have observed too few nests to accurately predict nesting success or rates of parasitism for this species. At this time we have no evidence of parasitism on solitaire nests, nor do we know of records from elsewhere in Colorado (Chace & Cruz, 1996).

Nest Site Selection: Solitaires nest in a wide variety of stands and do not appear to require shrubs or taller trees (Table 6). Where they do occur in ponderosa pines they seem to avoid the most open areas (Table 6), and we have found nests in doghair thickets on the Heil Ranch property owned by the county. This is a ground nesting species, and often nests in very open areas without much shrub cover. All nests we have located have been sheltered by an overhanging rock or stump.

Management Concerns: A primary concern for this species is its habit of nesting in relatively open situations on the ground. This may make it particularly susceptible to flushing when the nest is approached closely, and the nests may also be vulnerable to predation by dogs. Townsend's Solitaires are not common anywhere on open space properties near Boulder but appear to be more common on properties with low rates of visitation, such as the Heil Ranch property owned by the county. In addition, on CBOS properties they appear to be more common away from trails and roads. When occurring in ponderosa pine, solitaires seem to prefer thicker stands and extensive thinning could make habitat unsuitable. It is one of the few species we find nesting in doghair stands. In general, the thicker mixed conifer stands are probably more appropriate habitat than ponderosa pine stands.

Plumbeous Vireo *(Vireo plumbeous)*

Distribution and Abundance: Although nests are easy to locate, Plumbeous Vireos are generally uncommon on CBOS properties dominated by ponderosa pine forest and rare in higher elevation mixed conifer forest (Table 1). GIS Analysis failed to reveal any significant relationships between Plumbeous Vireo abundance and landscape level physiographic variables on CBOS properties.

Breeding Season: Breeding takes place from late May through early August with a peak during the month of June (Table 2). Later nests appear to be primarily second nesting attempts. We have no evidence of second broods.

Nesting Success: Nests contain 3-6 eggs with 3 or 4 being a typical clutch (Table 3). The nesting cycle for this species lasts about 28 days (Table 3). Plumbeous Vireo nesting success is high (Table 4), but this species is a primary host of the Brown-headed Cowbird in Colorado (Chace et al., 2000) and in northern New Mexico (Goguen & Mathews, 1996). Our study suggests that close to 40% of nests are parasitized on CBOS (Table 5). Many of these nests fledge only cowbirds, and it has been suggested that vireo populations on open space properties adjacent to Boulder residential areas may not produce enough young to maintain the population (Chace et al. 2000). However, logistic regression indicates that parasitism decreases dramatically as distance from the residential areas of Boulder increases (d.f. = 47, $X^2 = 6.16$, $P = 0.013$ (Chace et al., in prep.).

Nest Site Selection: Plumbeous Vireos prefer to nest in thicker woodland and forest stands and avoid open areas (Table 6). They do not appear to require larger trees or shrub cover (Table 6). Nests are typically placed in the lower portion of trees and near the tips of branches (Table 7). They are often very exposed from the side, but canopy cover is typically high over the nest (Table 7). Nests are normally placed in ponderosa pines, but some nests have been located in deciduous trees and shrubs.

Management Concerns: Plumbeous Vireos seem to adjust well to human related disturbance so long as their nests are not regularly disturbed. We have located many nests very close to trails. The primary concern for this species is the high rate of cowbird parasitism. Nests are more likely to be parasitized by cowbirds if they are on properties close to residential areas and/or trails (Chace et al., in prep). Parasitism also increases close to openings and in areas of low canopy cover (Chace & Cruz, 1999). Finally, this species appears to prefer to nest in moderately dense ponderosa woodland and forest, and extensive thinning may reduce densities.

Warbling Vireo *(Vireo gilvus)*

Distribution and Abundance: Uncommon in lower elevation riparian zones of CBOS, but more common in mixed conifer forests, especially where streamside riparian vegetation and/or aspen stands are present (Table 1). GIS analysis reveals that in ponderosa pine habitat Warbling Vireos are more common on steeper slopes ($P < 0.001$) and on slopes that receive little incident sunlight ($P = 0.002$) (model $R^2 = 0.361$), while in mixed conifer habitats they are more common near streams ($P = 0.021$) (model $R^2 = 0.189$). These patterns are probably related to the distribution of aspen and other deciduous trees across the landscape.

Breeding Season: Active nests have been located from early June through mid-July (Table 2). It is likely that breeding extends through late July in some cases. We have no evidence of second broods.

Nesting Success: This species appears to lay fewer eggs than the Plumbeous Vireo, with typical clutch size being 3 or 4 (Table 3). The nesting cycle lasts approximately 27 days (Table 3). About 40% of Warbling Vireo nests are successful (Table 4). However, as with the Plumbeous Vireo, the parasitism rate on nests is high (Table 5) and some nests only fledge cowbird young. Warbling Vireos in the eastern United States occasionally reject cowbird eggs from their nests (Sealy, 1996). This behavior has not been reported in the western U.S., but we have evidence of rejection of cowbird eggs from two nests on open space properties near Boulder.

Nest Site Selection: Warbling Vireos are found primarily in riparian areas, where they may be found nesting either in trees or shrubs. Tall trees do not appear to be a requirement, but shrub cover is often high around nest sites (Table 6). Nests are normally near the middle of branches, and often placed in the upper portion of the nest tree (Table 7). Canopy cover is almost always high at the nest site (Table 7).

Management Concerns: This species is tolerant of disturbance and nests have been located near trails. However, extensive patches of riparian vegetation appear to be a requirement and this habitat may be threatened by human use and the creation of social trails along streams. Cowbird parasitism may also be a threat. As with the Plumbeous Vireo, parasitism rates decrease away from residential areas (Chace et al., in prep.). However, cowbirds are most abundant in riparian areas (Table 1) and the rate of parasitism on this species is high close to Boulder.

Western Tanager *(Piranga ludoviciana)*

Distribution and Abundance: A generally common species throughout forested habitats in CBOS, tanagers appear to be most common where mixed conifer stands predominate (Table 1). GIS analysis reveals that in mixed conifer habitats tanagers are less common at higher elevations ($P = 0.046$), less common on steep slopes ($P = 0.075$), and less common on cooler slopes that receive less direct sunlight ($P = 0.044$) (model $R^2 = 0.361$). In ponderosa pine habitat tanagers are more common on steep slopes, however ($P < 0.001$) (model $R^2 = 0.191$). These patterns appear to be best explained by the Western Tanager's preference for moderately dense forest stands with a mix of coniferous trees.

Breeding Season: Breeding takes place from at least late May through late July with a peak during the month of June (Table 2). Later nests are probably second attempts after initial failures. We have no evidence for second broods.

Nesting Success: Western Tanagers almost always lay 4 eggs, with a few nests only containing a clutch of 3 (Table 3). The nesting cycle lasts about 25 days (Table 3). About 60% of Western Tanager nests successfully fledge young (Table 4). Parasitism by cowbirds appears to be high (Table 5), but may very dramatically from year to year (Fischer et al., in press). Our apparent rate of parasitism from CBOS may be higher than the actual rate since we located more nests with eggs in 2001, a year in which parasitism rates were very high. Some parasitized tanager nests fledge tanager young as well as cowbird young (Fischer et al., in press).

Nest Site Selection: Like Plumbeous Vireos, Western Tanagers appear to prefer moderately dense forest stands (Table 6). Nests are almost always in taller trees, but shrub cover is not necessary (Table 6). Nests in ponderosa pines are normally placed on a long branch about half way up the nest tree. The nests are typically located in an area of high canopy cover near or just beyond the midpoint of the branch (Table 7). For more details see Fischer et al. (in press).

Management Concerns: Since tanagers typically nests relatively high in taller trees and their nests are well hidden they do not appear to be affected much by human disturbance. They are probably regularly affected by thinning as their nests are difficult to locate and they do sometimes nest in denser forest stands. Tanagers appear to be a favorite host species for cowbirds in Boulder County.

Brown-headed Cowbird *(Molothrus ater)*

Distribution and Abundance: A generally uncommon species throughout CBOS, cowbirds are most common in lower elevation riparian zones and least common where mixed conifer forests predominate (Table 1). GIS analysis suggests this species becomes less common with increasing distance from Boulder residential areas ($P = 0.009$) and from roads and trails ($P < 0.001$) (model $R^2 = 0.270$).

Breeding Season: This species does not build its own nest, but lays its eggs in the nests of other species. Parasitized nests have been located from late May through late July. Parasitism appears to decline after early July.

Nesting Success: As this species does not make its own nest, we did not estimate nest success. Brown-headed Cowbirds parasitize a wide variety of species on CBOS (Table 5), and the nesting success of these species varies greatly.

Nest Site Selection: Cowbirds have been found to parasitize nests more often in open areas (Chace and Cruz, 1999). Parasitism rates also appear to be higher near residential areas (Chace et al., in prep.). Favorite host species on CBOS properties include Plumbeous and Warbling Vireos, Western Tanagers, and Spotted Towhees (Table 1). However, we also have evidence for parasitism on at least 10 other species.

Management Concerns: This is not a species of concern in its own right. However, it should be monitored due to its parasitic nature and potential impacts on other breeding species. Presently cowbirds are not particularly common near Boulder, which probably limits the amount of parasitism on local host species. Forest thinning and the creation of trails probably increases parasitism rates, however. Host species should be monitored in areas where extensive thinning is undertaken.

Black-headed Grosbeak *(Pheucticus melanocephalus)*

Distribution and Abundance: A common species in lower elevation riparian zones, but rare in coniferous habitats (Table 1). GIS analysis failed to reveal any significant patterns in grosbeak abundance in relation to landscape-level physiographic variables. This species appears to be common wherever there are extensive patches of shrubs and/or riparian vegetation.

Breeding Season: Active nests have been located from late May through mid-July with a peak in June (Table 2). Actual breeding probably extends into late July on some occasions.

Nesting Success: Typical grosbeak nests contain 3 or 4 eggs (Table 3). The nesting cycle lasts about 24 days (Table 3). Black-headed Grosbeaks have a high apparent nest success (Table 4), and their nests are rarely parasitized by cowbirds (Table 5).

Nest Site Selection: Grosbeaks almost always nest in thick shrub areas (Table 6) in riparian zones, although we have found a few nests in ponderosa pines. Tall trees are not a requirement, and this species appears most common in areas with fewer trees (Table 6). Nests are usually placed in the upper parts of taller shrubs or small deciduous trees.

Management Concerns: Black-headed Grosbeaks are tolerant of humans, and many nests have been located quite close to trails. They do appear to require extensive shrub thickets, however, and numbers may be reduced by habitat loss and social trails along streams. Cowbird parasitism does not appear to be a significant problem.

Spotted Towhee *(Pipilo maculatus)*

Distribution and Abundance: An abundance species throughout lower elevation riparian zones and in ponderosa pine forests where there is adequate shrub cover (Table 1). Uncommon in shrubby vegetation in higher elevation mixed conifer forests. In ponderosa pine habitat towhees are more common near streams ($P = 0.037$), and surprisingly more common close to roads and trails ($P = 0.005$) (model $R^2 = 0.273$). This is probably related to the higher shrub cover near streams and in the openings created by trails. No significant relationships were found between towhee abundance and landscape-level physiographic variables in mixed-conifer habitats.

Breeding Season: There is insufficient data for analysis. Active nests have been located from late May through late July (Table 2).

Nesting Success: Most towhee clutches appear to contain 3 eggs, though 4 egg clutches are also found (Table 3). The nesting cycle of this species is very short, lasting only about 22 days (Table 3). The apparent nesting success of this species is low (Table 4), and nests are often parasitized by Brown-headed Cowbirds (Table 5). Our estimates may be skewed however, as most Towhees appear to nest in very dense shrub thickets. We probably only find the nests that are easiest to locate and these may be parasitized and/or predated at a higher than normmal rate.

Nest Site Selection: Towhees nest on or near the ground in very dense shrub thickets. They do not require trees, but shrub cover is a necessity (Table 6).

Management Concerns: Spotted Towhees are very common in areas of CBOS with extensive shrub patches. They are somewhat tolerant of humans, and disturbance to most nests is unlikely due to the placement in dense shrub thickets. Both the rates of predation and cowbird parasitism may be concerns, but it is not clear if these rates are affected by our ability to find nests only in relatively open situations.

Chipping Sparrow *(Spizella passerina)*

Distribution and Abundance: Abundant throughout ponderosa pine forested properties owned by CBOS, more local in higher elevation mixed conifer forests (Table 1). GIS analysis suggests they are less common in areas with steep slopes ($P < 0.001$) (model $R^2 = 0.216$).

Breeding Season: Breeding takes place between late May and mid-August with a peak in June (Table 2). Many late nests are probably second nesting attempts as we have documented multiple broods on several occasions.

Nesting Success: Chipping Sparrow nests usually contain 3 or 4 eggs (Table 3). Like the Spotted Towhee, the nesting cycle of this species is short (22 days) (Table 3). Some pairs renest while still caring for dependant fledgelings. Chipping Sparrows have very low apparent nest success (Table 4), but may make up for this by having multiple nesting attempts each season. The rate of parasitism on Chipping Sparrow nests is relatively low on CBOS (Table 5), though much higher rates of parasitism have been documented elsewhere in Colorado (Ortega & Ortega, 2001).

Nest Site Selection: Chipping Sparrows nest in coniferous trees and saplings and in dense shrub patches. They are quite general in their habitat requirements and do not need tall trees or shrub cover (Table 6). They do seem to prefer thinner stands, however (Table 6). Nest placement is likewise very general. Nests may be low or high and anywhere within a tree or shrub (Table 7). Most nests are well hidden in dense clusters of needles or leaves.

Management Concerns: Chipping Sparrows are common throughout CBOS and, therefore, do not appear to be threatened. The one major concern appears to be the high rate of nest failure. However, the Chipping Sparrow's ability to raise multiple broods may make up for this problem. Cowbird parasitism is low on CBOS properties and does not appear to be a significant problem. Chipping Sparrows are very tolerant of human disturbance. In addition they would likely benefit from most forest thinning practices.

Lesser Goldfinch *(Carduelis psaltria)*

Distribution and Abundance: Generally uncommon and local in riparian zones and ponderosa pine forest on CBOS properties (Table 1). Abundance varies from year to year, possibly in response to availability of food resources. GIS analysis failed to reveal significant patterns in goldfinch abundance in relation to landscape-level physiographic variables.

Breeding Season: This is the latest breeder among the species analyzed. Nesting takes place primarily between early June and late August (Table 2), and may even extend into early September in some cases. The peak of the season is quite late, encompassing most of July. We have documented attempts to raise second broods on two occasions, and late nesting dates are probably second attempts (Prather et al., in review).

Nesting Success: Goldfinch clutches contain 3 – 5 eggs with an average clutch of 4 (Table 3). The nesting cycle lasts an average of 27 days (Table 3). However, some pairs appear to be able to renest due to the extended breeding season shown by this species. The apparent nesting success of this species is very high (Table 4), perhaps because females show extremely high rates of nest attentiveness during the incubation period and the early part of the nesting period (Prather et al., in review). The estimate of the rate of parasitism on CBOS (Table 5) is probably far too high as the one parasitized nest we located on Enchanted mesa is the only one we have encountered during our study (Prather et al., in review). An additional sample of 21 nests from the Heil Ranch property were all unparasitized.

Nest Site Selection: Lesser Goldfinches nest in a variety of locations including coniferous and deciduous trees and in shrub patches. Most nests on CBOS properties have been placed in tall conifers. They do not seem to require tall trees, however, nor do they require shrub cover (Table 6). They appear to prefer to nest in savannah areas or on the edges of forest, rather than in thick stands (Table 6). Nest placement is normally in a dense cluster of needles or leaves near the tip of a branch (Table 7). Most nests are about halfway up the nest tree (Table 7). For more detail see Prather et al. (in review).

Management Concerns: Goldfinches vary considerably in abundance from season to season, but are generally common and there do not appear to be reasons for concern. Nests are typically so well hidden that they are unlikely to be noticed by people even when close to trails. In addition, female goldfinches sit tightly on their nests, often not moving unless touched (Prather et al., in review). They appear very tolerant of disturbance. Nest success is high and parasitism seems to be rare in this area. Forest thinning practices should benefit goldfinches since they prefer open habitat.

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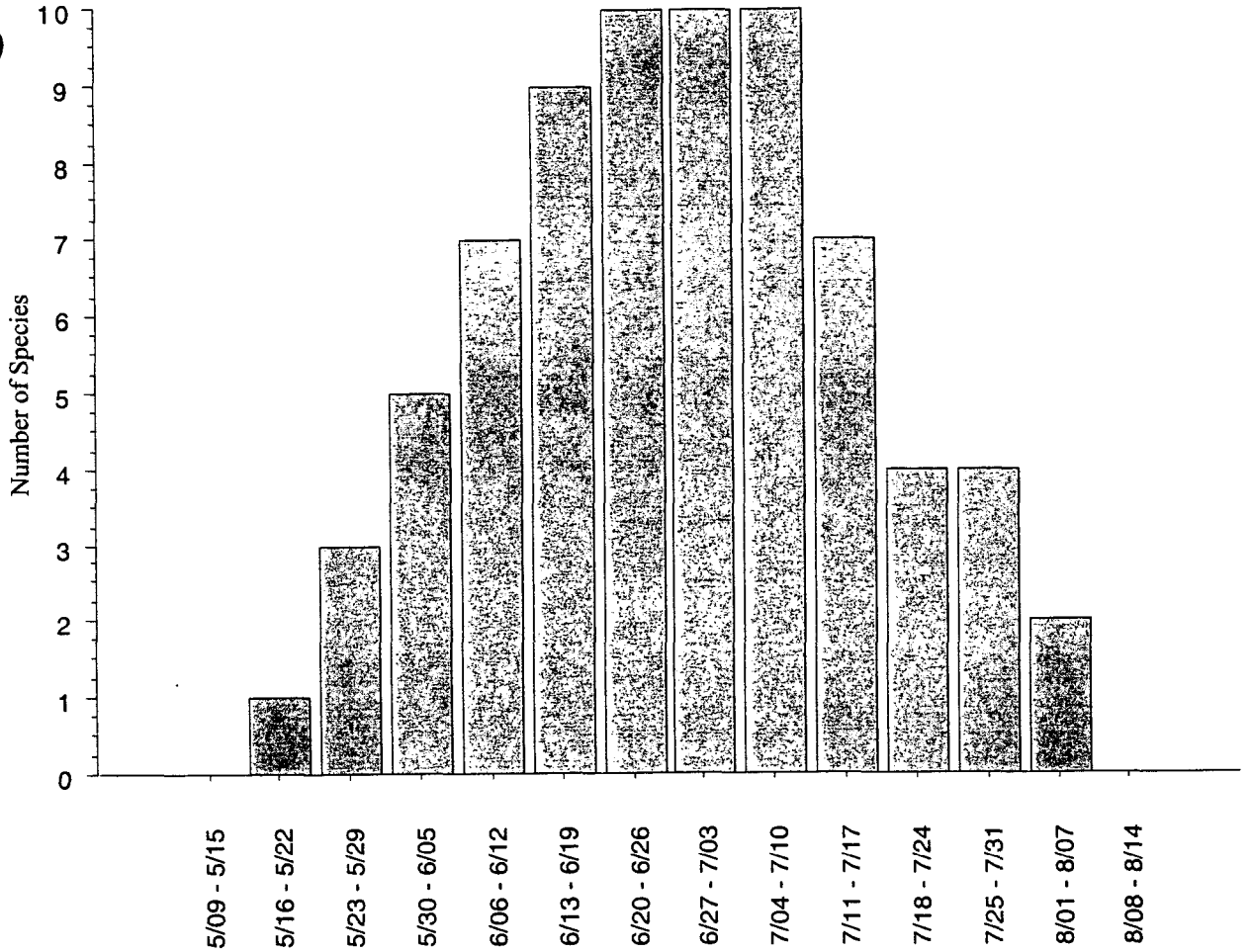

Figure 1: Number of species (out of 10) with at least 25% of nests on CBOS properties active in a given week between mid-May and mid-August.

Table 1: Relative abundance (mean ± SD pairs/ha) of selected avian taxa on City of Boulder Open Space and Mountain Parks properties 1999-2001.

Species	Riparian (n = 15)	Ponderosa Pine (n = 91)	Mixed Conifer (n = 28)
Mourning Dove	----	0.15 ± 0.25	----
Broad-tailed Hummingbird	1.01 ± 0.64	0.45 ± 0.48	0.47 ± 0.37
Western Wood-Pewee	0.14 ± 0.21	0.95 ± 0.77	----
Hammond's Flycatcher	----	0.15 ± 0.34	0.32 ± 0.46
Blue-gray Gnatcatcher	0.13 ± 0.45	0.26 ± 0.33	----
American Robin	0.69 ± 0.36	0.66 ± 0.45	0.78 ± 0.47
Townsend's Solitaire	----	----	0.14 ± 0.19
Plumbeous Vireo	----	0.29 ± 0.42	0.14 ± 0.20
Warbling Vireo	0.34 ± 0.44	0.09 ± 0.27	0.53 ± 0.59
Western Tanager	0.35 ± 0.40	0.49 ± 0.45	0.82 ± 0.59
Brown-headed Cowbird	0.45 ± 0.35	0.26 ± 0.33	0.15 ± 0.20
Black-headed Grosbeak	0.44 ± 0.34	----	0.12 ± 0.19
Spotted Towhee	1.57 ± 0.87	1.03 ± 0.89	0.26 ± 0.48
Chipping Sparrow	----	1.04 ± 0.78	0.45 ± 0.43
Lesser Goldfinch	0.34 ± 0.41	0.47 ± 0.59	----

Table 2: *Breeding phenology for selected* avian taxa on City of Boulder Open Space and Mountain Parks properties.

Species	N	Start	1st Quartile	Peak	3rd Quartile	End
Mourning Dove	16	18 May	16 June	26 June – 16 July	29 July	4 August
Broad-tailed Hummingbird	20	18 May	6 June	12 June – 28 July	3 August	14 August
Western Wood-Pewee	70	23 May	14 June	22 June – 22 July	28 July	12 August
Hammond's Flycatcher	05	26 May	----	----	----	20 July
Blue-gray Gnatcatcher	06	25 May	----	----	----	26 July
American Robin	28	13 May	17 May	28 May – 19 June	13 July	5 August
Townsend's Solitaire	04	7 June	----	----	----	8 August
Plumbeous Vireo	30	21 May	31 May	5 June – 3 July	17 July	5 August
Warbling Vireo	12	5 June	10 June	14 June – 8 July	13 July	17 July
Western Tanager	24	27 May	2 June	4 June - 28 June	6 July	28 July
Black-headed Grosbeak	12	24 May	26 May	30 May – 25 June	10 July	13 July
Spotted Towhee	04	27 May	----	----	----	23 July
Chipping Sparrow	26	23 May	27 May	2 June – 18 June	7 July	11 August
Lesser Goldfinch	28	31 May	20 June	27 June – 25 July	3 August	21 August

Table 3: Nesting data (Mean ± SD) for selected avian taxa on City of Boulder Open Space and Mountain Parks properties.

Species	Clutch Size	Incubation Period	Nestling Period
Mourning Dove	2.0 ± 0.0 (n = 34)	14.0 ± 1.5 (n = 06)	11.0 ± 1.0 (n = 09)
Broad-tailed Hummingbird	2.0 ± 0.0 (n = 20)	17.0 ± 1.5 (n = 03)	19.0 ± 3.0 (n = 08)
Western Wood-Pewee	2.9 ± 0.6 (n = 85)	16.0 ± 2.0 (n = 38)	14.5 ± 2.5 (n = 39)
Hammond's Flycatcher	3.8 ± 0.4 (n = 05)	14.0 ± 0.0 (n = 01)	19.5 ± 3.5 (n = 02)
Blue-gray Gnatcatcher	3.7 ± 1.2 (n = 06)	11.0 ± 0.0 (n = 01)	13.0 ± 2.5 (n = 03)
American Robin	3.4 ± 0.8 (n = 24)	13.5 ± 1.5 (n = 07)	12.0 ± 1.5 (n = 10)
Townsend's Solitaire	3.7 ± 0.5 (n = 06)	12.0 ± 3.0 (n = 02)	14.0 ± 3.0 (n = 02)
Plumbeous Vireo	3.7 ± 0.5 (n = 28)	15.5 ± 1.5 (n = 17)	13.0 ± 1.5 (n = 19)
Warbling Vireo	3.5 ± 0.6 (n = 04)	14.0 ± 3.0 (n = 02)	13.0 ± 2.0 (n = 06)
Western Tanager	3.8 ± 0.4 (n = 10)	12.5 ± 1.5 (n = 03)	12.0 ± 2.0 (n = 04)
Black-headed Grosbeak	3.4 ± 0.5 (n = 09)	12.5 ± 2.5 (n = 03)	11.5 ± 2.0 (n = 06)
Spotted Towhee	3.3 ± 0.9 (n = 08)	12.0 ± 0.0 (n = 01)	10.0 ± 2.0 (n = 05)
Chipping Sparrow	3.5 ± 0.7 (n = 32)	12.5 ± 1.5 (n = 05)	10.0 ± 1.5 (n = 05)
Lesser Goldfinch	3.8 ± 0.6 (n = 29)	14.0 ± 1.5 (n = 17)	13.0 ± 1.5 (n = 17)

Table 4: Nesting success of selected avian taxa on City of Boulder Open Space and Mountain Parks properties 1999-2001.

Species	N	Successful Nests	Predated Nests	Abandoned Nests	Unknown Nests	Mayfield Nest Success
Mourning Dove	11	4	2	2	3	45.0 %
Broad-tailed Hummingbird	23	16	2	1	4	72.3 %
Western Wood-Pewee	77	51	12	2	12	67.7 %
Hammond's Flycatcher	06	5	1	0	0	----
Blue-gray Gnatcatcher	11	6	3	0	2	45.4 %
American Robin	22	9	2	1	10	65.0 %
Townsend's Solitaire	04	1	2	1	0	----
Plumbeous Vireo	43	28	6	2	7	74.9%
Warbling Vireo	11	6	2	2	1	40.1%
Western Tanager	18	11	1	0	6	58.8 %
Black-headed Grosbeak	14	11	2	0	1	67.3 %
Spotted Towhee	12	3	6	0	3	33.6 %
Chipping Sparrow	27	12	8	3	4	32.9 %
Lesser Goldfinch	10	5	1	0	4	80.4 %

Table 5: Cowbird parasitism rates on selected avian taxa on City of Boulder Open Space and Mountain Parks properties 1999-2001.

Species	N	Unparasitized Nests	Parasitized Nests	Unknown Nests	Apparent Parasitism Rate
Mourning Dove	11	11	0	0	00.0 %
Broad-tailed Hummingbird	23	18	0	5	00.0 %
Western Wood-Pewee	77	60	0	17	00.0 %
Hammond's Flycatcher	06	4	0	2	----
Blue-gray Gnatcatcher	11	7	1	3	12.5 %
American Robin	22	10	0	12	00.0 %
Townsend's Solitaire	04	4	0	0	----
Plumbeous Vireo	43	25	14	4	35.9 %
Warbling Vireo	11	6	4	1	40.0 %
Western Tanager	18	4	6	0	60.0 %
Black-headed Grosbeak	14	7	1	3	12.5 %
Spotted Towhee	12	6	4	2	40.0 %
Chipping Sparrow	27	17	3	7	15.0 %
Lesser Goldfinch	10	4	1	5	20.0 %

Table 6: Macrohabitat characteristics (90% C.I.) of nest sites of selected avian taxa on City of Boulder Open Space and Mountain Parks properties *1999-2001*.

Species	N	Canopy Height	Percent Shrub Cover	Stand Density (Stems/Ha)
Mourning Dove	23	07.6 – 16.6	0.0 – 44.3	00 - 591
Broad-tailed Hummingbird	11	10.0 – 14.2	0.0 – 29.7	02 - 920
Western Wood-Pewee	110	10.7 – 15.7	2.0 – 24.4	62 - 288
Hammond's Flycatcher	10	11.8 – 17.8	0.0 – 21.6	107 - 663
Blue-gray Gnatcatcher	16	10.0 – 13.6	6.8 - 43.4	33 - 339
American Robin	17	05.8 – 15.6	0.0 – 50.8	50 - 266
Townsend's Solitaire	10	08.8 – 15.4	0.0 – 25.1	101 - 305
Plumbeous Vireo	45	08.3 – 15.9	0.0 – 31.1	213 - 565
Warbling Vireo	16	05.5 – 17.5	7.6 – 36.0	162 - 416
Western Tanager	34	11.3 – 15.5	0.0 – 25.9	192 - 454
Black-headed Grosbeak	20	02.3 – 07.5	13.4 – 52.4	11 - 231
Spotted Towhee	10	10.8 – 17.6	10.5 – 55.5	65 - 325
Chipping Sparrow	36	08.5 – 16.3	0.0 – 25.5	85 - 327
Lesser Goldfinch	25	10.3 – 17.9	0.0 – 28.1	34 - 212

Table 7: Microhabitat characteristics (90% C.I.) of nest sites of selected avian taxa on City of Boulder Open Space and Mountain Parks properties *1999-2001.*

Species	N	Percent Canopy Cover	Percent Branch Length	Percent Tree Height
Mourning Dove	23	44.1 – 88.1	31.0 – 60.8	26.0 – 65.0
Broad-tailed Hummingbird	11	63.4 – 91.0	23.8 – 78.4	18.9 – 43.3
Western Wood-Pewee	110	42.1 – 91.7	39.5 – 72.3	17.2 – 51.2
Hammond's Flycatcher	10	64.1 – 98.1	13.3 – 60.7	33.0 – 72.4
Blue-gray Gnatcatcher	16	49.1 – 89.1	29.7 – 63.3	20.5 – 65.3
American Robin	17	37.3 – 99.9	00.0 – 61.1	22.2 – 60.0
Townsend's Solitaire	10	21.9 – 74.3	----	----
Plumbeous Vireo	45	64.9 – 84.5	53.6 – 97.0	16.3 – 55.1
Warbling Vireo	16	69.9 – 99.9	20.6 – 56.7	46.5 – 81.3
Western Tanager	34	60.3 – 89.5	56.0 – 83.6	36.8 – 65.4
Black-headed Grosbeak	20	42.3 – 88.5	0.00 – 47.7	53.9 – 85.1
Spotted Towhee	10	31.0 – 71.2	----	----
Chipping Sparrow	36	41.5 – 82.3	20.3 – 87.5	13.2 – 57.2
Lesser Goldfinch	25	41.7 – 67.9	64.0 – 99.9	30.8 – 63.8